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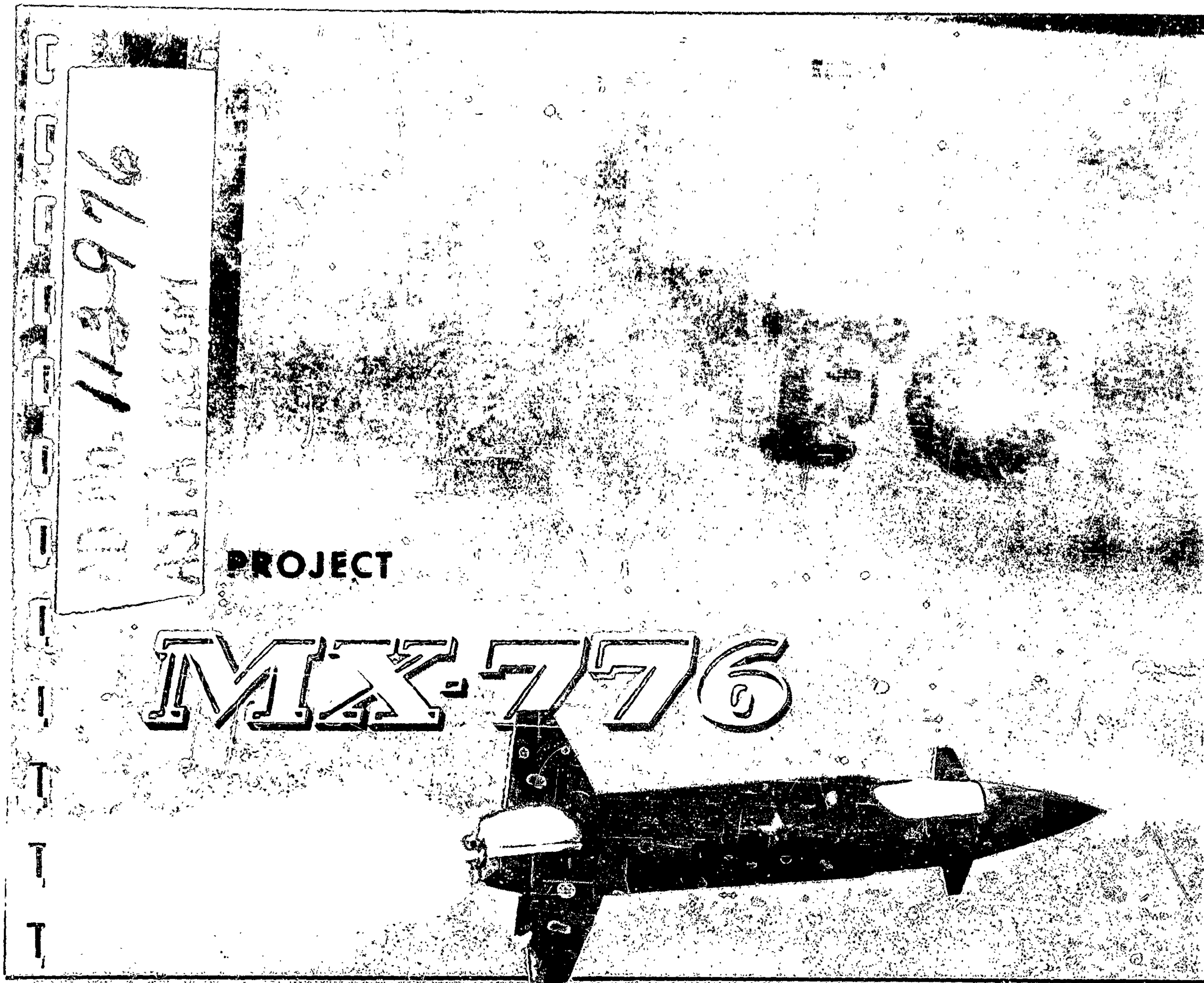

QUARTERLY PROGRESS REPORT

REPORT NO. 56-981-021-46

BELL Aircraft CORPORATION

30 SEPTEMBER 1956

SECRET

SECRET

145

PROJECT

MX-776

QUARTERLY PROGRESS REPORT

30 SEPTEMBER 1956

DEC 1956

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SUMMARY

The Bell Aircraft Corporation presents here a brief resume on the status and progress of major elements and efforts of the MX-776 Rascal Weapon System for the quarter ending 30 September 1956.

RELIABILITY . . . reliability control charts for the factory-test phase are now based upon a weapon system reliability goal of 70% . . . previous interim goal was 50%. . . . In the Missile Life Test Program, airframe No. 78 was subjected to a series of composite systems tests (less propulsion) . . . observed reliability of the missile is 79.05% as compared with a reliability goal of 60.5%. . . . Nine YLR-67-BA-9 rocket engines have passed the vibration acceptance testing program . . . improvement in reliability as each succeeding engine was tested verified design improvements and significant decrease in malfunctions due to human errors. . . . Presentation of the second reliability educational film to manufacturing personnel is scheduled for early in October 1956.

FLIGHT TEST PROGRAM . . . at Holloman Air Development Center, two missiles (Nos. 4176 and 4277) were launched during this quarter. . . . XGAM-63 No. 4176 was released from a DB-36 director aircraft on 6 August . . . all flight objectives were accomplished . . . operation of the YLR-67-BA-9 power plant was excellent . . . at a missile range of 66 nautical miles the XGAM-63 was directed to a direct hit through the target plane. . . . XGAM-63 No. 4177 was launched from a DB-47 director on 11 September . . . operation of the weapon system was satisfactory until 14.8 seconds after umbilical separation when the destruct system was inadvertently activated and a normal break-up of the missile occurred . . . an immediate investigation resolved the most probable cause of the destruct signal and the recommended corrective action has been initiated. . . . The captive flight test program is continuing at HADC to gather additional performance and environmental data during in-flight operation of missile and director aircraft systems.

AIRFRAME . . . investigation of rain-erosion protection of the missile's radome determined that the present nose coating offers the greatest erosion resistance of nonmetallic materials. . . . Silicone hydraulic fluid XF 4270 is being evaluated for use in the GAM-63 hydraulic system . . . results of tests with this low-viscosity fluid indicate excellent lubricity and no appreciable wear of pump parts. . . . A missile destructor system of improved design to replace the present primacord charge has been proposed to the WSPO. . . . Studies to simplify the circuitry of the GAM-63 electrical system have led to successful tests on several miniaturized components offering up to 50% savings in both size and weight. . . . The feasibility of launching the GAM-63 at an altitude of 10,000 feet has been investigated . . . a flight profile was prepared; results indicate that the present weapon system configuration offers no fundamental obstacles to launching at this altitude.

PROPULSION SYSTEM . . . the YLR-67-BA-9 rocket engine with the Bell-designed turbine pump has successfully passed Preliminary Flight Rating Tests. . . . In the engine development program a new design, designated YLR-67-BA-11, has evolved . . . the -11 engine will utilize IRFNA and incorporate a dual fly-ball governor speed control . . . model specifications and details for a Preliminary Flight Rating Test program have been submitted to the WSPO for approval . . . qualification testing of the -11 rocket engine is scheduled for completion during the first half of 1957. . . . Three additional turbine pump assemblies from the recently established production line have successfully passed acceptance testing. . . . The aluminum fuel and oxidizer tanks have passed qualification testing . . . fabrication is proceeding at an increased level.

GUIDANCE SYSTEM . . . improvements in AGC for the missile's radar set are being evaluated during captive flights at HADC. . . . Work on the high-power radar set for the missile continues . . . tests on a newly fabricated receiver assembly indicate a decrease of 3 to 5 db in the noise level. . . . In the program to locate a reliable power-transmitting tube for the radio repeater set, a Raytheon backward-wave tube has proved satisfactory for Rascal relay application. . . . Components of the inertial range-computing system are being evaluated under extreme environmental conditions . . . repackaging of the three computers used in the system will improve operational reliability. . . . The Electronics Vulnerability Test Program is under way at HADC to determine the susceptibility of the Rascal weapon to interception and analysis, and the degree of interference of missile performance that can be introduced by jamming and deception.

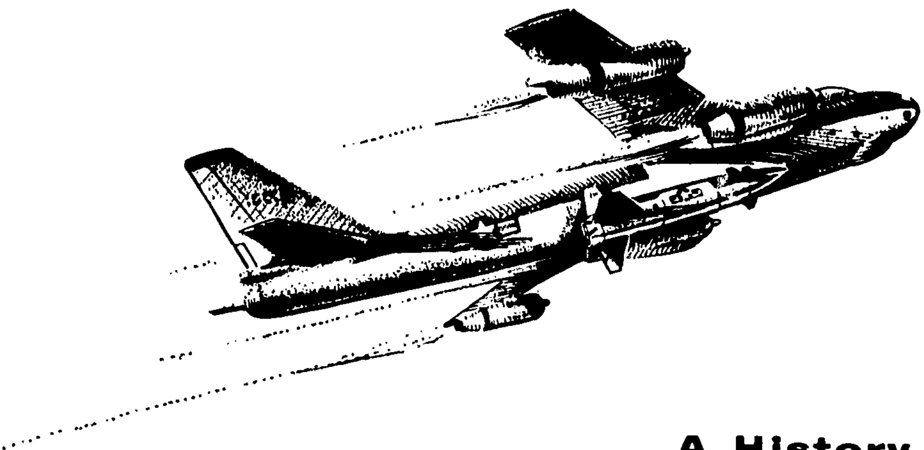
FLIGHT CONTROL SYSTEM . . . in the re-evaluation program on the Rascal flight control system and the inertial range-computing system, more than 1100 environmental tests have been conducted on production models of electronic and hydraulic components. . . . Missile No. 46 is being used to investigate various mechanical coupling effects between the airframe and such pickoff elements as gyros and accelerometers. . . . A program to improve the over-all reliability of the flight control system is in the second of two phases.

GROUND SUPPORT EQUIPMENT . . . a program is under way to evaluate the operational equipment required to service, test, and otherwise prepare the weapon system for a mission . . . items of support equipment are being used during preflight preparations in conjunction with applicable handbooks to ensure compatibility between equipment and handbook.

TRAINING EQUIPMENT . . . all but three of the 25 units comprising both the missile and director aircraft portions of the Mobile Training Unit for teaching theory of operation and techniques of maintenance in the field have been released for manufacture. . . . The Rascal Guidance Operator Trainer (RGOT) is undergoing changes to keep the configuration up to date . . . a new optical system for the radar simulator is being constructed and an all-optical target briefing device is being designed and fabricated. . . . Phase III of the Target Acquisition Program has been completed . . . SAC Air Observer Bombardiers conducted 18 dives with the JF-80 (simulated GAM-63) airplane against a radar bomb scoring site at Phoenix, Arizona . . . guidance of the JF-80 was accomplished from a DB-36 director aircraft under realistic operational conditions. . . . .RGOT map-making techniques were evaluated by the Radar Bombing Branch, Offutt AFB and a report of their findings is anticipated in the next quarter. . . . A packaging analysis report for the Rascal weapon is in the final stages of preparation prior to publication.

CONTENTS

ILLUSTRATIONS



SECTION I

INTRODUCTION

A. History of Project MX-776

The MX-776 Rascal project was initiated by the Air Materiel Command, USAF, as a study program for the development of a subsonic air-to-surface missile (ASM) carrying a special warhead. This program was later amended to include a supersonic ASM; eventually, the subsonic missile phase was discontinued.

In 1948, Project MX-776 was divided into two concurrent programs, MX-776A (Shrike) and MX-776B (GAM-63 Rascal). Bell Aircraft Corporation, as the prime Weapon System Contractor, immediately initiated the design, development, and fabrication of Shrike, a supersonic test missile (small-scale version of the GAM-63) with a 50-mile range and capable of carrying a 1000-pound warhead. Work on the missile radar relay system included the use of two B-17's as a simulated missile/director aircraft team. These early investigations and subsequent work with modified F-80 and F-89 aircraft have resulted in an improved guidance system for installation in the GAM-63.

In 1950, Bell Aircraft was authorized to proceed with the detail design and fabrication of GAM-63 missiles, and the first powered Shrike missile was launched successfully from a DB-50 airplane.

A major milestone was passed in September 1952 when the first GAM-63 was flown under its own power. By the end of 1952, the Shrike program, which included 28 powered missiles, was successfully completed. At the close of 1953, two glide and four powered GAM-63's had been flight-tested, the last containing full guidance equipment.

During 1954, the capabilities of the Rascal Weapon System were amply demonstrated during the flight testing of 18 missiles. These capabilities were demonstrated in search radar and microwave link operation, power plant performance and control, remote control of the missile during terminal guidance, and missile performance at high altitudes. A free-drop configuration and technique was devised and successfully proven during the launching of 10 missiles; the technique is now standard procedure. Vital structural and aerodynamic data were obtained from the flight test program. Pinpoint accuracy was demonstrated by missile No. 1626* which, under full guidance control, scored the first target bull's-eye of the Rascal flight test program.

In the first quarter of 1955, six GAM-63 missiles were launched from DB-50 director aircraft. Two missiles, Nos. 2231 and 2430, scored direct target hits at missile ranges of approximately 38 nautical miles. This concluded the flight testing of Model D missiles and the use of B-50's as director aircraft.

On 5 May 1955, the first operational prototype missile of the Model F series, GAM-63 No. 2849, was launched from a DB-36 director aircraft. This missile included inertial guidance and a simulated warhead. Missile No. 3054, launched 14 July 1955, was the first released from a DB-47 director.

Late in 1955, the MX-776 development program was reorientated to emphasize reliability in the Rascal weapon system. A firm comprehensive test program was established to provide an over-all increase in operational reliability with each successive missile. Repetitive acceptance and life tests, hot

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* The first two digits of the missile number indicate firing order; the last two digits indicate USAF airframe delivery number. Thus, missile 1626 is the 16th to be launched, but the 26th airframe delivered to the USAF.

ground firings, and captive flight tests are providing a weapon of continually increasing reliability.

During the third quarter of 1956, GAM-63's Nos. 4176 and 4277 were launched in the flight test program at Holloman Air Development Center, New Mexico. Detailed flight test results are presented in Section II, B.

B. Weapon System Description

WEAPON SYSTEM

Designed as an all-weather airborne instrument of combat, the Rascal GAM-63 Weapon System provides strategic bombardment aircraft with an increased capability for attacking and destroying heavily defended targets with little possibility of being detected or intercepted. Major elements of the weapon system are (1) the GAM-63 missile, (2) the DB-47 director aircraft, (3) ground support equipment, and (4) training aids.

RASCAL MISSILE

The GAM-63 is a rocket-propelled, air-to-surface, guided aircraft missile with a gross weight of approximately 18,500 pounds, half of which is propellants. Principal dimensions are: over-all length, 32 feet; maximum outside body diameter, 4 feet; and maximum horizontal span, 17 feet. The missile airframe combines a cylindrical semimonocoque fuselage with a canard cruciform wing configuration. Structurally, the airframe consists of five major sections: the radome nose, forward body, warhead section, center body (tank) section, and aft body shell. These divisions are based upon functional requirements as well as system and component accessibility and ease of shipment.

For its specific employment in the Rascal Weapon System, the GAM-63 comprises four closely integrated component systems: (1) a liquid-propellant rocket power plant, (2) a servopilot and antenna stabilization system, (3) a range-computing inertial guidance system incorporating a radar relay and command override feature, and (4) a special warhead and fuzing system. The rocket power plant, utilizing fuming nitric acid and jet fuel as propellants, delivers 12,000 pounds thrust to accelerate the GAM-63 to supersonic velocity during its climb to cruise altitude. During the gyro-stabilized midcourse portion of flight, the missile follows a programmed course as dictated by its inertial guidance system. A range computer measures the horizontal distance traveled from the point of launch and causes the missile to enter a preset dive to target. During the terminal dive, a search radar in the radome of the GAM-63 scans the target area and relays missile position and target data to a guidance station in the director aircraft. This information is used to establish course-correcting command signals that are relayed to the GAM-63 as required to hit the target.

DIRECTOR AIRCRAFT

The director aircraft that form an integral element of the Rascal Weapon System are modified B-47 strategic bombardment airplanes, redesignated DB-47. Their primary mission is to carry the GAM-63 missile to a point within 90 nautical miles of a target and to provide for its proper launching and guidance after launch. In addition to an MA-8 bombing-navigational system, the director aircraft are equipped with (1) automatic equipment to check out the GAM-63 quickly and completely before launch and, working in conjunction with the MA-8 system, to release the missile automatically; (2) a relay link system to establish and maintain continuous microwave contact with the missile; and (3) a control station that permits a guidance operator to monitor the flight path of the missile and, if necessary, to initiate course corrections during the midcourse and terminal dive phases of flight.

GROUND SUPPORT EQUIPMENT

Items of ground support equipment for the GAM-63 Weapon System are separated into three major categories: servicing, handling, and checkout. This equipment encompasses all items that are not an integral part of the missile or director aircraft, but are necessary to service, repair, test, and otherwise prepare the weapon for its mission. Servicing equipment includes items such as the fuel and oxidizer trailers and the nitrogen boost trailer. Handling and transport items comprise carriages and dollies, assembly stands and slings, and packaging equipment. Checkout and test equipment is provided for the maintenance of electronic, electrical, and hydraulic systems in both the missile and director aircraft.

TRAINING EQUIPMENT

Rascal training equipment provides the means for indoctrinating and training maintenance and operations personnel of the Air Force in various phases of weapon system application. Equipment required by the Air Force comprises a mobile trainer unit for teaching theory of operation and techniques of maintenance in the field, and an operational procedure trainer for guidance operators. Additional equipment includes: mobile classroom demonstrators containing functional component systems of the missile and director aircraft; flight teams of F-80/B-50 aircraft modified to simulate the GAM-63/DB-47 combination in actual air-to-surface training; and appropriate spare parts, test units, bench test sets, and instruction manuals.

C. Weapon System Mission

The Rascal Weapon System* is designed to carry out air-to-surface bombing of strategic targets without exposing the bombardment airplane and aircrew to local target defenses. This mission is accomplished by combining a high-performance DB-47 bomber airplane with a relatively short-range, supersonic, GAM-63 missile. In its operational employment, the weapon system is based upon the ability of the missile to penetrate local defenses and to deliver a 2800-pound special warhead to a strategic target with little probability of being detected or intercepted. Thus, DB-47 strategic bombers as director aircraft armed with GAM-63 missiles need not approach the target closer than 90 nautical miles, the range of the missile.

An Air Force letter dated November 1953 established a maximum range requirement of 90 nautical miles for the Rascal missile. Based upon a missile range of 75 nautical miles, the GAM-63 will provide an airburst with a horizontal circular probable error (CEP**) not greater than 1500 feet and, excluding errors in weather prediction and target intelligence, a vertical standard deviation*** not greater than 405 feet.

In a typical maximum-range mission, the DB-47 director aircraft, carrying the GAM-63 missile, is navigated to a predetermined launch area by means of its MA-8 bombing-navigational system which constantly computes distance and course to the target. Immediately prior to launch, an automatic checkout system (ACS) checks critical items of the missile in sequence, while data regarding director aircraft velocity, heading, and changes in range-to-target are fed into the missile to serve as "initial condition" data for its nonemanating guidance system. At a preset distance from the target, the ACS, in conjunction with the MA-8 system, automatically releases the GAM-63 on the proper heading for the target. Minimum launch altitude is 40,000 feet MSL; minimum launch velocity is Mach 0.78. As the missile clears the launch gear of the DB-47, the rocket engine ignites. The GAM-63 accelerates to supersonic velocities in its climb to cruise altitude as programmed by a pressure-sensing circuit. During its climb and cruise to the point of terminal dive, the missile is controlled by a gravity-referenced inertial guidance system. The missile's range computer measures ground range to target by double integration of a signal from a pitch-stabilized accelerometer. At a pre-established distance from the point of launch, the range-computing system places the GAM-63 in a 35° dive toward the target.

At the initiation of terminal dive, a search radar mounted in the nose of the missile is automatically activated and scans the area ahead of the GAM-63 over a 150° sector. A radar image of the target and surrounding area, complete with missile position and heading, is sent via a microwave relay link to the director aircraft. Here, the radar information, displayed on a plan position indicator, enables a guidance operator to monitor the progress of the flight and to ascertain the missile's position relative to the target. If the GAM-63 is headed off course, guidance commands in pitch and azimuth can be computed and transmitted via the relay link to override the missile's autopilot. This is accomplished as the operator manipulates a tracking stick to align

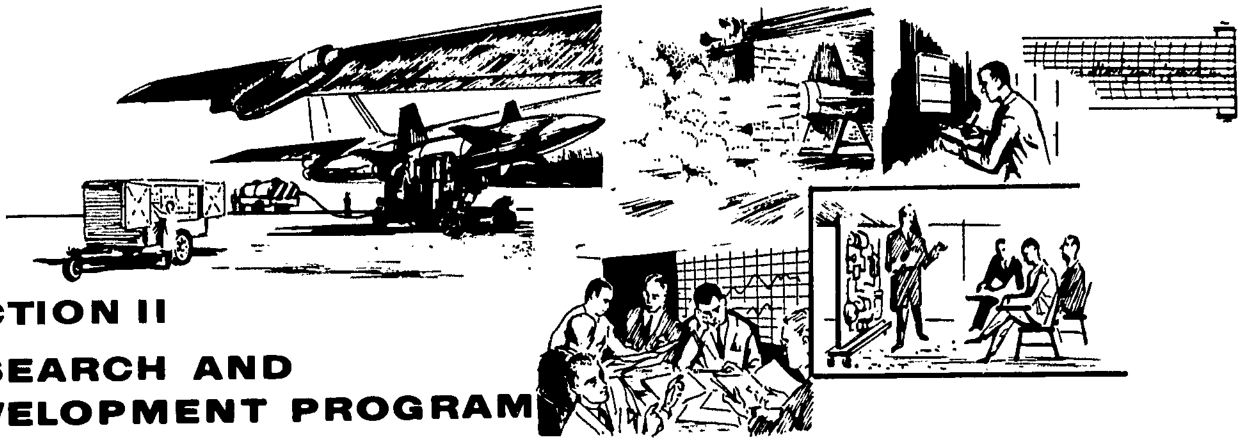
* "Military Characteristics for a Pilotless Parasite Bomber," SAB-51-B1, 14 December 1951, Directorate of Requirements, Hdq. USAF; "Development Directive," No. 00-27-A1, 4 February 1952, ARDC; and "Reorientation of Project MX-776, Contract W33-038ac-14169," AF letter WCSGA/HDH/nrw, 4 March 1952.

** CEP: The limiting value, as the number of flights becomes large, of the radius of a right circular cylinder whose axis is a vertical line through the target and within which 50% of the detonations occur.

*** VERTICAL STANDARD DEVIATION: The limiting value, as the number of flights becomes large, of the root-mean-squared distance between the actual and intended detonation altitude.

cursors on the radar display in coincidence with the target. Displacement of the tracking stick determines the magnitude of the flight path corrections which are automatically computed and relayed to the missile's autopilot system. With the radar definition of the target area constantly improving as the GAM-63 approaches its objective, the required degree of accuracy in target acquisition is assured.

It is important to note that the guidance operator may, at any time after launch, initiate a command to energize the search radar in the missile. The relayed video information can be utilized to check and correct the flight path of the GAM-63 in relation to known checkpoints. Also, the terminal dive can be initiated through the command link.



SECTION II
RESEARCH AND DEVELOPMENT PROGRAM

A. Ground Test Program

1. SYNOPSIS

As the Rascal Weapon System progresses from the R & D stage to the fabrication of prototype operational configurations, an increasing amount of final testing and evaluation of equipment is undertaken. The major effort is directed toward (1) systems testing of components and subsystems, (2) flight testing of GAM-63's, and (3) evaluating prototypes of director aircraft and ground support equipment. In such a testing program, system deficiencies are pinpointed and corrective development work is accomplished concurrently with the evaluation of the weapon system and its elements.

Presented here is the progress being made in systems testing of various elements of the weapon system.

2. TESTING AT THE WHEATFIELD FACILITY

a. Missile Test Stations

The Missile Laboratory at Bell Aircraft's Wheatfield plant maintains two R & D test stations for evaluating engineering changes and/or development problems which affect systems test operations. Each test station is capable of complete systems testing (excluding "hot" propulsion tests) of electrical, electronic, and hydraulic systems of the GAM-63.

b. Missile Testing

(1) XGAM-63 No. 78

The Life Test Program conducted on XGAM-63 No. 78 was completed during this quarter. The missile was subjected to 60 composite systems tests which consisted of one reference composite, 50 composites under normal operating conditions, and nine composites during which time the missile was vibrated. Figure 1 shows the preparation of XGAM-63 No. 78

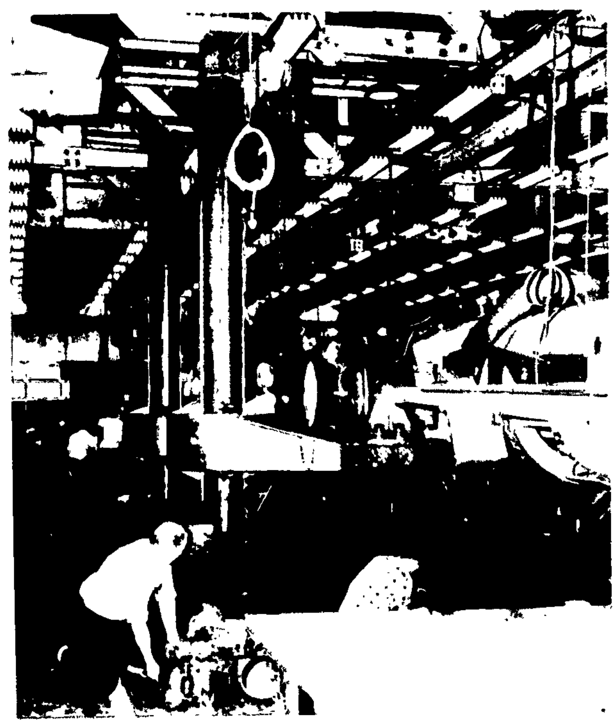


Figure 1. Preparation of Missile No. 78 for Lateral Plane Vibration Testing

for lateral plane vibration. Report 56-987-164, "Composite Systems Tests on GAM No. 78," has been published. This report presents the test procedures and resultant data of the 50 composite systems tests. Report 56-987-168, "Vibration Testing of GAM No. 78," is being published to present information on the other nine composite tests.

Missile No. 78 is presently being modified in preparation for a simulated profile mission test. The missile will undergo an eight-hour period of vibration after which a composite systems test will be conducted.

(2) XGAM-63 No. 80

Alignment tests are being performed to assure required operation of the limited life replacement components recently installed in XGAM-63 No. 80. Upon completion of these tests, the missile will be shipped to HADC.

(3) XGAM-63 No. 70

Testing has been completed on the fin hydraulic and electrical systems for XGAM-63 No. 70. The hydraulic system was revised and the electrical system changed to the same configuration, effective on missile No. 4075. This is in preparation for the Angular Coincidence Studies to be conducted at Holloman Air Development Center.

c. Missile Equipment

Systems testing of components and subsystems designed for GAM-63 missiles is performed to ensure the satisfactory operation of these units under environmental conditions that will be encountered in actual field operations.

To accomplish environmental testing, both conventional and specialized test facilities are employed. These include vibration, shock, acceleration, and radio interference equipment; temperature, humidity, and altitude chambers; and chambers for proof-testing under conditions of sand and dust, frost, and explosion.

Systems testing of missile components and subsystems at the Wheatfield plant has been completed in accordance with Bell Aircraft Report 56-989-129. Test reports are now available for the servo-electronic, servo-hydraulic, and electrical components, as well as for the radar set and the radio repeater set.

d. Director Aircraft Equipment

Preproduction systems testing of the terminal guidance system (TGS is part of the AN/APW-17 system) is progressing. This work is being accomplished in accordance with Bell Aircraft Specification 110-947-043. Testing is in the third of three phases.

Phase I was performed with the TGS separated into its five subsystems. Testing was conducted under environmental conditions of temperature, altitude, vibration, shock, frost, humidity, and crash safety.

Phase II was conducted with the five subsystems operating as a complete terminal guidance system. All components of the TGS, normally supplied and integral to the guidance capsule, have been tested satisfactorily under specified testing; all test reports have been forwarded to WSPO. A life test (1000 hours duration) has been completed successfully; the test report will be published early in the next quarter.

Phase III of this test program is approximately 60% complete. Forty-two TGS units of a total of 46 have undergone explosion-proof tests with no failures. Thirty of the 42 units have been exposed to conditions of sand and dust with no failures. High-frequency vibration without isolators has been performed on 9 of the 30 units with only minor failures being noted.

e. Miscellaneous

(1) Missile

Re-evaluation testing of the radar set and radio repeater set (following systems tests) has been completed successfully and the reports are being prepared. Re-evaluation testing of the servo-electronic components is continuing. During these tests, drift was noted in the output signal under conditions of low temperature. A redesign of the spin drive amplifier has been undertaken to eliminate this condition.

Special environmental inspection tests have been completed satisfactorily on 11 sets of modified telemetering systems. Five of these sets are 16-channel systems and the remaining six are 20-channel systems. An additional four sets are undergoing tests which should be completed during the next quarter.

Life testing (1000 hours duration) of a radio set subsystem is in progress. To date, 775 hours of operating time have been accumulated. During this time, seven part failures were encountered and it was necessary to readjust potentiometer settings 11 times to compensate for drift.

Susceptibility tests on the S- and L-band beacons have been completed successfully according

to the requirements of MIL-I-6181B. At present, susceptibility tests are being conducted on the radio set subsystem. The radar set subsystem, telemetering subsystem, and servo and inertial guidance subsystems are also scheduled for susceptibility testing.

Tests under the combined environments of temperature, altitude, and vibration have been completed satisfactorily on four servo amplifiers. Plans call for two additional servo amplifiers to be subjected to this test. Combined environmental tests are also scheduled on two types of blower assemblies and a relay used in the Rascal missile.

Evaluation testing is under way on encapsulated and hermetically sealed transformers and reactors. A redesign of the mounting brackets for the transformers was necessary because of failures occurring during vibration testing. An evaluation test of lightweight Selenium transformer rectifiers has indicated the possibility of reducing by two-thirds the weight and space requirements of the d-c power supply.

Time-delay relays, which are smaller and lighter than those presently used in the missile, are undergoing evaluation tests.

A prototype of the redesigned servo power supply has been subjected to vibration tests without isolators. Vibration testing at an acceleration of 10g in the frequency range of 5 to 500 cps was performed satisfactorily without isolators.

A resonance scan vibration test was performed on the YLR-67-BA-9 rocket engine to determine fatigue points and reliability of component installations; only minor failures were noted. A series of frequency scan tests was conducted on the -9 gas generator package to determine the natural frequencies of its components. The results of this test are being analyzed.

The possibility of using Barry "All-Angl" vibration isolators on Rascal components is being investigated.

(2) Director Aircraft

Tests are planned to determine the possibility of reducing noise within the AN/APW-17 guidance system. These tests are tentatively scheduled to start in January 1957.

Special environmental inspection testing is continuing on the AN/APW-17 guidance equipment returned from HADC. Systems Nos. 3, 5, 6, 7, 11, 12, and 14 have been tested successfully and shipped to HADC; system No. 13 is presently undergoing tests.

Special tests have been performed successfully on the alternate warhead "black boxes" from two AN/APW-17 guidance systems.

(3) Ground Support Equipment

It has been decided that preproduction testing of ground support equipment will be performed to a limited extent only. Test procedures and planning on this program have been halted.

A total of four GAM-63 airborne simulators (Bell Dwg. 112-542-500-1) has been tested and delivered. Four additional units are to be tested. Also, one GAM-63 simulator of the -5 configuration will be tested.

Pre-evaluation tests have been completed on the general purpose hoisting sling, warhead loader, forward body stand, hoist support boom, and aft body stand. The test reports are being published.

During this quarter, a program was initiated to determine the compatibility of the operational, service, and field maintenance handbooks with the operational test equipment. The handbooks are being reviewed for the sequential continuity and proper utilization of the emanating guidance, nonemanating guidance, fuzing, and calibration bench set equipment, and the missile checkout trailer. The test program for evaluating the handbooks is approximately 20% complete.

3. TESTING AT AIR FORCE PLANT NO. 38

a. General

The MX-776 testing program at Air Force Plant No. 38 consists of composite systems testing of GAM-63 missiles and inspection testing of rocket thrust chambers, turbine pumps, gas generators, and rocket engines. In composite testing, all systems of the GAM-63, including the rocket engine, are operated and checked simultaneously to ascertain the effect each system has on the others.

Nine cells are used for inspection testing: one for rocket engines, one for gas generators, one for thrust chambers, one for turbine pumps, and five for composite systems. Additional qualification testing, including attitude tests and environmental tests over a temperature range of -65° to +140°F, can be conducted at this site.

b. Thrust Chambers

Six additional thrust chambers have passed acceptance testing. Water flow and hydrostatic pressure checking of thrust chamber shells, and high-pressure methylene chloride flushing of propellant valves, continue in the Water Flow Building located near Cell E-5 (see Figure 25).

c. Turbine Pump Assemblies

Nine inspection tests were conducted during this quarter and four turbine pump assemblies were accepted for use in rocket engine assemblies.

d. Gas Generator Packages

Inspection testing of gas generator packages is under way in Cell E-4. Both ambient and cold tests have been conducted. The test facility at Cell E-4 was completely checked out and three gas generator packages were accepted during the quarter.

e. Rocket Engines

Twelve inspection tests, conducted in Test Cell E-3, resulted in the acceptance of four YLR-67-BA-9 rocket engines.

f. Tank Pickling

Pickling of aluminum oxidizer tanks prior to installation in missiles is continuing in Test Cell E-4. Twelve tanks were processed during this quarter.

g. GAM-63 Missiles

Testing was completed on missile No. 4176 and the GAM-63 was transferred to the Wheatfield plant in preparation for shipment to HADC.

Missile No. 4277 was tested in Cell E-5. This included a cold temperature (-55°F) composite systems test with propulsion (see Figure 2). Over-all performance of missile No. 4277 indicated an improvement over the previous missiles, Nos. 4075 and 4176. Cleanup of minor discrepancies was conducted and No. 4277 was transferred to the Wheatfield plant in preparation for shipment to HADC.

GAM-63 No. 79 was tested in Cell E-9 where an ambient composite systems test with propulsion was performed. Trouble-shooting was then conducted on the various problems encountered. These were primarily minor telemetering system troubles and two tube failures in the servo and inertial range-computing

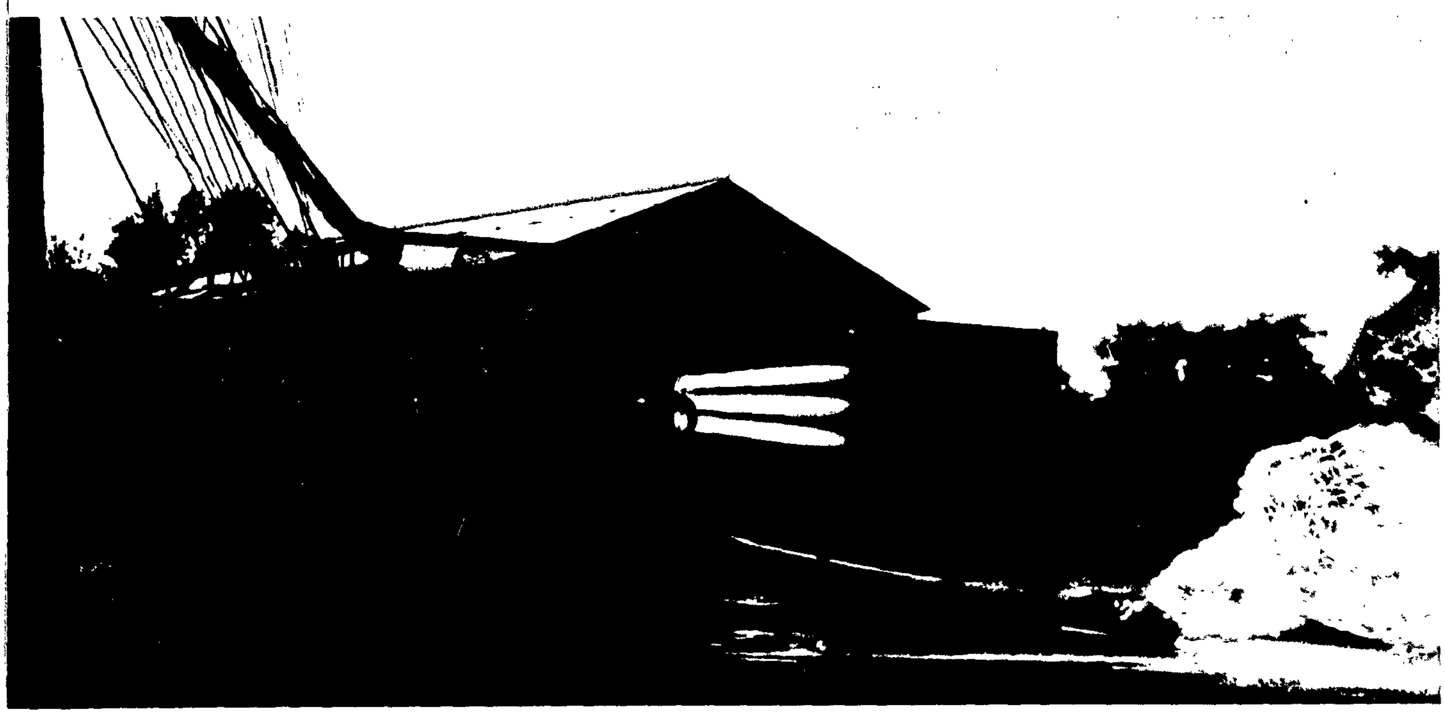


Figure 2. Composite Systems Testing of Missile 4277 at Air Force Plant No. 38

systems. A final composite systems test was then performed to indicate satisfactory missile operation. Missile No. 79 was subsequently returned to the Wheatfield plant in preparation for shipment to HADC.

Missile No. 81 was received at AF Plant No. 38 and was installed in Cell E-9 where preparations are being made to perform an ambient composite systems test with propulsion.

B. Flight Test Program

1. SYNOPSIS

Forty-two Rascal missiles have been expended in the flight test program at Holloman Air Development Center (HADC), New Mexico. Of these, 27 were launched from DB-50 airplanes, thereby completing the final testing of Model 56A, B, and D missiles. The remaining 15 XGAM-63 firings utilized the Model 56F configuration and either the DB-36 or the DB-47 as director aircraft.

During this quarter, two XGAM-63 missiles (Nos. 4176 and 4277) were launched at HADC. The first, No. 4176, was released from a DB-36 director aircraft; missile No. 4277 was launched from a DB-47.

2. FLIGHT TEST PLANS

Final flight test plans including the latest changes in the MX-776 program have been completed for XGAM-63's Nos. 79 and 80.

3. FLIGHT TEST REPORTS

Analysis of data from the final flight of GAM-63 No. 4176 has been issued in the Bell Aircraft Data Reduction Report, No. 56-980-238. The Data Reduction Report for the flight of missile No. 4277 is being reviewed prior to publication.

4. CAPTIVE FLIGHT TESTING

The captive flight test program at HADC was continued during this quarter to gather performance and environmental data during in-flight operation of missile and director aircraft systems.

Three captive flights were conducted with airframe No. 61 and a DB-47 airplane (see Figure 3) to isolate the cause of multiple heading markers and PPI sweep collapse previously encountered during captive flights with missile No. 4277. Further ground tests and in-flight checks are under way to investigate this terminal guidance problem.

Observations and data from captive flights and hot firings have established that operation of the AGC circuit in the missile's radar set is marginal during terminal dive. To improve the AGC operation, a method is being evaluated for changing the AGC threshold voltage to 85% of its present value at a

Figure 3. DB-47 Taking Off with Rascal Missile

predetermined altitude. In conjunction with this program, two captive flights were conducted during this quarter. Results of these flights indicate an improvement in the video contrast at lower altitudes with AGC switching; however, equipment malfunctions precluded the possibility of determining whether or not the improvement was sufficient to give satisfactory video level at all altitudes. The tests will be continued during the next quarter.

Following the flight tests conducted in the fuel spillage program during the last quarter, the Boeing Airplane Company installed an additional strip of guttering on the DB-47 (USAF No. 51-5220). The new gutter extends aft 96 inches from a point directly under the fuel vent of the righthand (forward) main tank. Also, a new type of pylon seal was installed.

To check the effectiveness of these installations, a captive flight was conducted on 13 September 1956. A discarded water tank was mounted in the bomb bay of the DB-47 with tubing and electrical cordages installed so that a dye water solution could be discharged from the fuel vent of the righthand forward main tank when the copilot initiated the action. The right side of the airplane, the pylon, and a section of the missile were painted with white calcimine to assure a well-defined dye pattern for study. The dye water was spilled during a take-off run at a speed of approximately 115 knots. This simulated fuel spillage from the fuel vent of the forward main tank that might occur on an aborted take-off.

An examination of the dye pattern following the flight indicated the effectiveness of the new gutter drain. There were no traces of the dye water on the forward edge of the pylon, at the umbilical plug area, or in the capsule cooling duct. Although the new pylon seal appeared to offer an improvement over the original seal, there was evidence of leakage between the seal and the skin of the DB-47. The dye pattern is shown in Figure 4; the cooling duct in the forward edge of the

Figure 4. Dye Pattern on DB-47 after Testing New Gutter Drain

pylon is partly obscured by the upper rudder of the missile.

5. MISSILE LAUNCHINGS

a. XGAM-63 No. 4176

Missile No. 4176 was transferred to HADC on 11 June 1956. Following receiving inspection, the GAM-63 was prepared for a series of captive flights. A total of four captives were conducted to verify satisfactory operation of the missile and director aircraft systems.

At 0523 hours MST on 6 August 1956, following a preflight check out, XGAM-63 No. 4176 and DB-36 (USAF No. 51-5710) became airborne for the launch mission (see Figure 5). Primary objective of the flight test was to evaluate the YLR-67-BA-9 power plant under operational environmental conditions.

After prelaunch checks in accordance with HADC procedure proved satisfactory operation of the weapon system, the DB-36 was vectored onto the firing line. The final prelaunch checks proceeded through the automatic countdown and the missile was released at 0709 hours, 60.6 seconds after range coincidence. Launch altitude was 44,180 feet MSL (42,110 feet pressure altitude) at Mach 0.60. Distance from launch point to target was 66.15 nautical miles.

The missile separated cleanly from the pylon and the director aircraft began a procedural turn to the left. Just prior to completing this 197° turn (at +77.4 seconds), the automatic relay antenna system locked on to the radar return from the missile. At +77.6 seconds, the S-meter reading began to rise and, from this point on, the relay link between the missile and director aircraft was firmly established.

During its climb and cruise to terminal dive, the GAM-63 reached a maximum altitude of 59,420 feet at 144.5 seconds and a maximum velocity of Mach 2.66 at 137.5 seconds.

The missile's search radar was activated by command from the guidance operator at +92.0 seconds; the flight was subsequently monitored by the operator until impact. When the slant-range cursor and the target became coincident on the radar scope in the director aircraft (+195.1 seconds), the guidance operator initiated a dive command as per flight plan instructions that overrode the programmed dive of the inertial range-computing system and the missile nosed

Figure 5. XGAM-63 Missile and DB-36 Director Aircraft

toward the target. This occurred 1.3 seconds before the planned automatic dive and 13.24 nautical miles from the target. The missile responded quickly and properly to this dive command.

All data indicate that the primary purpose of the mission was fulfilled; the -9 power plant with the Bell-designed turbine pump operated satisfactorily during all phases of the flight. Autopilot operation was normal. Small oscillations in pitch, yaw, and roll were damped out within 20 seconds after missile release. The L-band and S-band beacon systems functioned properly.

Operation of both the nonemanating and the emanating guidance systems was satisfactory. In addition to the terminal dive command, the guidance operator initiated a series of pitch and azimuth commands to direct the GAM-63 through the target plane. Miss distance at target altitude offset (10,000 feet MSL) was:

Radial	605 feet
Range	370 feet over
Azimuth	480 feet to the right

The 16-channel and 4-channel telemetering systems of the missile provided satisfactory results with a few minor exceptions. Environmental data were obtained successfully except for information from the two vibration accelerometers and one temperature pickup. Askania and photographic coverage was adequate.

All adequate data on this flight have been reduced and studied. A flight test report, incorporating the results of complete analyses, is being compiled.

Shown in Table I is the launch and performance data for missile No. 4176. The sequence of events for the flight is as follows:

	Time in Seconds
Range Coincidence (Start of ACS Countdown)	- 60.6
Test to Normal (Range-Computing System)	- 58.6
Turbine Fire	- 30.6
Transfer from External to Internal Power	- 19.2
Enable (Angular Coincidence Circuit Armed)	- 0.6
Gyro Uncage	- 0.5
Release (Automatic Checkout System)	- 0.2
Release (Umbilical Plug)	- 0.1
Release (Lanyard)	0.0
Rocket Fire	1.9
Full Thrust Attained	3.9
Altitude Controller Connected	32.7
Relay Link Lock-on	77.6
Radar Set Commanded On	92.1
Rocket Shutoff	137.5
Dive Command (Guidance Operator)	195.1
Dive Command (Range Computer)	196.4
Arming Baroswitch Activation	238.9
Switch to High PRF	245.9
Fuzing Baroswitch Activation	254.1
Impact	261.0

TABLE I

LAUNCH AND PERFORMANCE DATA
XGAM-63 NO. 4176

	Planned	Actual
Launch Data		
Pressure Altitude (Feet)	42,500	42,110
Mach Number	0.60	0.60
Target Distance (N. Mi.)	65.0 ±1.9	66.15
Performance Data		
Max. Pressure Altitude (Feet)	60,000	58,050
Max. Mach Number	2.47	2.66

b. XGAM-63 No. 4277

Rascal missile No. 4277 was transferred to HADC on 9 July 1956. The effectiveness of the MX-776 Reliability Program is reflected in the fact that no discrepant items were noted during the receiving inspection of this GAM-63.

Four captive flights were conducted with this missile and the DB-47 airplane (USAF No. 51-5219). Difficulties experienced with operation of the terminal guidance control system led to the decision to use the other DB-47 airplane (USAF No. 51-5220) for the hot firing. Following a satisfactory pit check of the weapon system, preparations were made for the launch mission. Take-off occurred at 0559 hours MST on 11 September 1956. During the climb to altitude and throughout the dry run, the weapon system was subjected to a preflight check in accordance with HADC procedures. When the check revealed that system operation was satisfactory, the DB-47 was vectored onto the firing line and a final prelaunch countdown was begun. This resulted in the automatic launch of the GAM-63 at 0749 hours.

Operation of the weapon system was entirely satisfactory until 14.8 seconds after umbilical separation when the destruct system was inadvertently activated. A normal break up of the missile resulted immediately. Since this was an unwanted destruct and the reason for activation of the destruct circuit was not readily apparent, an investigating board was convened. The investigation board resolved the most probable cause of the destruct signal and the recommended corrective action was subsequently accomplished.

A preliminary analysis of power plant data indicates a satisfactory start and normal performance of the rocket engine throughout the initial by-pass phase. Following umbilical separation, transition to boost was accomplished as planned. Good engine performance was observed throughout the flight.

In-flight operation of the servo control system was normal. The automatic checkout system (ACS) failed to pass function No. 11, servo 5.4-kc reference frequency oscillator voltage, just prior to launch. Telemetering records indicate 39.6 rms volts at this time (specification calls for 40 ±2 volts). However, the ACS actually measures d-c voltage which is obtained from a rectifier in the missile. Since the 5.4-kc voltage is rectified before measurement, it is possible that a component failure occurred in the rectifier. Other possible causes for the failure of the ACS to checkout this function are:

(1) An unfavorable build-up of tolerance throughout the system.

(2) A poor umbilical plug contact.

During the prelaunch countdown, illumination of the rudder "zero" light indicated that the 5.4 kc voltage was approximately normal. Therefore, the ACS was advanced manually to function No. 12 and operation was satisfactory to achieve automatic release of the missile. Checks following the flight test failed to reveal the reason for function No. 11 being rejected by the ACS.

Performance of the terminal guidance control system was satisfactory throughout the prelaunch checks and until the missile was destructed.

Although operation of the radio repeater set in the director aircraft was satisfactory, the relay receiver did not energize after the guidance "ON" switch was activated. The receiver came on when the equipment was recycled. For the remainder of the flight, receiver operation was normal and the undesirable condition could not be made to recur during subsequent ground tests.

Analysis of telemetered data indicates that operation of the radar set and the radio repeater set in the missile was normal. Also, the inertial range-computing system functioned satisfactorily through the flight.

The quality of telemetering records was generally good. The only discrepancies noted were:

(1) Oxidizer case pressure gage was inoperative.

(2) Pressure reading was low for boost No. 1 thrust chamber.

(3) Calibration shift occurred in both the range and velocity signals.

The pressure gages from the oxidizer case and the boost chamber are being investigated to determine the cause of malfunction. Reasons for the calibration shifts have not yet been determined.

Director aircraft records were of good quality. All telemetering channels (including switch pips) operated satisfactorily. It was not necessary to correct any calibrations for shifts.

Aerial motion picture coverage of the preflight and launch phases was obtained from an F-94 chase airplane. Immediately after launch, the missile was lost by the camera and was not picked up again until after destruction. A T-33 chase airplane was unable to get close enough for desirable still-coverage of the flight.

Six GSAP cameras were mounted on the director aircraft. Four of the six cameras operated satisfactorily. Also, the terminal guidance cameras functioned adequately.

A sequence of events for the final flight of missile No. 4277 is presented in the following:

Event	Time in Seconds
Range Coincidence (Turbine Arm)	-92.7
Test to Normal (Range-Computing System)	-90.8
Turbine Fire	-67.4
Transfer from External to Internal Power	-54.5
Enable (Angular Coincidence Circuit Armed)	- 1.35
Angular Coincidence	- 1.30
Gyro Uncage	- 1.24
Release (Automatic Checkout System)	- 0.2
Release (Umbilical Plug)	- 0.1
Release (Lanyard)	0.0
Rocket Fire; Interference Appears on Command Receiver AGC Channel	1.8
Full Thrust Attained	3.6
Interference Ends on Command Receiver AGC Channel	7.2
Destruct	14.8

C. Reliability Program

The reliability program encompasses all phases of weapon system development and manufacture, and extends from initial research and design phases through operational considerations for the use of the finished product. Consequently, many of the specific reliability considerations and improvements realized in this quarter appear under other appropriate sections of this report. This section outlines some of the general programs of the reliability effort and discusses reliability activities and accomplishments that are not integral to specific areas of the weapon system covered separately in this publication. In addition, some specific examples of reliability improvements are given.

Detailed reliability information may be found in the MX-776 Quarterly Reliability Report, Bell Aircraft Report 56-989-111, for the period ending 31 August 1956.

1. RELIABILITY CONTROL

The progressive improvement of weapon system reliability requires close managerial control of all phases of the reliability effort. Statistical evaluation of discrepancies which occur during the testing of components, systems, and weapon systems, together with the actions of Discrepancy Analysis Teams and special analysis groups, has enabled Bell Aircraft to pinpoint trouble areas and take corrective action.

a. Reliability Control Charts

Reliability Control Charts are compiled periodically to show the observed reliabilities of components, subsystems, systems, and the entire weapon. Charts are based upon missile factory-test data and contain observed reliabilities determined by failure rates during and subsequent to the first composite systems test of each missile. To obtain more significant reliability figures, data on three consecutive missiles are used and the up-to-date value of the charts is ensured by revisions twice each month. Charts are also compiled showing the observed reliabilities of director aircraft and missile components, based on field discrepancy data obtained at HADC. Reliability Control Charts for GAM's Nos. 77, 79, and 80, including data through 30 August 1956, are published in the latest MX-776 Quarterly Reliability Report, No. 56-989-111.

b. Discrepancy Indices

Discrepancy indices provide another tool useful to management as a quantitative measure of trouble during functional testing of components. All discrepancies encountered in this phase of testing are utilized in the calculation of these indices. Special analyses of the components having the lowest discrepancy indices are published so that necessary corrective action can be instituted.

2. RELIABILITY ADVANCES

The reliability control charts for the factory-test phase are based upon a weapon system reliability goal of 70%. This is an increase from the previous interim goal of 50%. A redistribution of individual component and system reliability goals is also reflected in the charts, based upon recent revisions to complexity scale factors of individual parts.

The number of functional failures used to calculate observed reliabilities has been decreasing at a

significant rate during factory testing on the missiles. In light of this, for the six weeks ending 30 September 1956, the observed weapon system reliability has exceeded the new 70% reliability goal.

During the final flights of GAM's Nos. 75 and 76, the reliabilities of all systems were observed to be 100%.

3. COMPONENT LIFE TEST PROGRAM.

a. YLR-67-BA-9 Rocket Engine

Life testing on the YLR-67-BA-9 rocket engine has been completed and the final report is being

b. Unattended Search Radar Subsystem, Radar Set AN/DPS-3 (Less Servo Components)

The 1000-hour life test on the receiver-transmitter, modulator, and synchronizer, conducted as a bench test under normal ambient conditions, has been completed and a detailed report is being written. The seven reliability-type discrepancies encountered during the test were parts failures. The resultant observed reliabilities are well above the reliability goals for these three components. The original 4J52 magnetron survived the entire test; the tube accumulated approximately 690 operating hours. During the 1000-hour test, only 11 adjustments were made subsequent to the initial setup adjustments.

c. Relay and Command Subsystems, Radio Set AN/DSW-1 (Less Servo Components)

Testing is continuing, with 876 hours of the planned 1000-hour test completed.

d. Fuzing System Components

The 900 testing cycles (approximately 450 hours) have been completed. Test data are being analyzed.

e. Beacons and Destructor Assembly

Life testing began at Telerad, Flemington, New Jersey, during August 1956, with 1000 hours planned. To date, the S-band beacon has accumulated 184.7 hours and the L-band beacon 78.6 hours of testing.

f. Servo Amplifiers (Modified)

The pilot yaw, vertical gyro, erection, pitch pilot, and stable platform amplifiers have completed 501 cycles (167 hours) of combined environmental testing. The pilot roll and relay antenna stabilization amplifiers will begin testing early in October 1956.

g. Missile Simulator Group

The life test on the missile simulator group, an electronic assembly capable of simulating the electrical circuits in the GAM, was completed.

With the system being cycled every four minutes, the 1000 hours of operation were equivalent to 15,000 flights. No component failures were experienced.

4. MISSILE LIFE TEST PROGRAM

The life test program for XGAM-63 No. 78 was established as part of the Rascal reliability program. Upon completion of manufacturing subsystem testing, GAM No. 78 entered the Missile Laboratory on 25 May 1956. The following missile subsystems were monitored throughout testing:

(1) Emanating Guidance

(2) Nonemanating Guidance

(3) Servo

(4) Telemetering (4-channel)

(5) Range Beacon and Destructor

(6) Fuzing

Testing was divided into main groups, with one reference test preceding each group in the following order:

(1) One reference composite systems test to check missile conformance with final specifications prior to the start of testing.

(2) Phase A: Fifty composite system tests at ambient temperature (no vibration).

(3) One reference composite test to ensure that the missile was still within specifications.

(4) Phase A_1: Nine composite tests while the missile was being subjected to vibratory accelerations considered to be the maximum level likely to be experienced in actual captive and free flight.

The discrepancies used to calculate observed reliabilities were parts failures and certain necessary adjustments resulting from out-of-specification conditions in the equipment.

The initial reference composite test was completed on 13 June and the last of 50 Phase A composites on 13 August. The missile was then sent to the flight hangar for installation of the power plant. The engine was installed because the rocket engine ballast originally planned was not available.

Upon return to the Missile Laboratory, the second reference composite was completed on 17 August and the last of the nine phase A_1 vibration composite tests was completed on 30 August.

Table II is a summary of the discrepancies and reliabilities observed during life testing in phase A.

5. ENVIRONMENTAL DATA-COLLECTING PROGRAM

The environmental instrumentation installed in GAM's Nos. 63, 64, 75, 76, and 77 has yielded valuable temperature and vibration data from ground tests, captive flights, and free flights. Data have been reduced and are being studied.

Extensive data were obtained from the free flights of GAM's Nos. 63, 75, and 76. A preliminary review indicates that the vibratory accelerations on the basic missile structures during free flight were less than those recorded on GAM's Nos. 19 and 20. Probably the largest single factor contributing to these lower levels is due to the revised flight plan which permits the missile to pass through the transonic speed range in level flight.

The temperature data recorded during the captive and free flights of these missiles did not exceed the temperatures specified in the Bell Technical Data Reports, Nos. 56-947-200, 56-947-210, and 66-989-019. Therefore, it appears that these specification temperature requirements are adequate.

6. YLR-67-BA-9 ROCKET ENGINE VIBRATION TESTS

A total of nine engines has been vibration-tested since the initiation of the vibration acceptance test program for the YLR-67-BA-9 rocket engine. The discrepancies which occurred during each test were recorded and classified by type of failure such as leaks, parts rubbing, parts damaged, and undesirable clearance. The results of the tests to date show that 60% of the reported discrepancies were encountered during the testing of the first three engines. This large percentage may be attributed to either or both of the following causes:

(1) More stringent input levels of vibration were imposed on the first three engines.

TABLE II

SUMMARY OF OBSERVED DISCREPANCIES AND RELIABILITIES DURING LIFE TESTING OF XGAM-63 NO. 78 (Phase A)

SYSTEM AND SUB SYSTEMS	NUMBER OF RELIABILITY DISCREPANCIES	OBSERVED RELIABILITY	RELIABILITY GOAL (31 AUG 56)
GAM NO. 78	33	79.05	60.5
1 PROPULSION	NA	NA	
2 FLIGHT CONTROL	9	91.78	86.5
A. SERVO POWER SUPPLY	7	93.28	97.38
B. PITCH	0	100	96.56
C. YAW	1	99.38	97.21
D. ROLL	1	99.01	97.51
E. STABLE PLATFORM	0	100	97.04
3 NONEMANATING GUIDANCE	1	99.49	96.0
4 EMANATING GUIDANCE	23	86.57	88.0
A. RADAR SET	17	91.14	93.09
B. RADIO SET	6	94.99	94.54
5 AUXILIARY	0	100	96.0
6 FUZING	0	100	98.0

NA—NOT APPLICABLE FOR TESTING

(2) Certain inadequacies in design have since been eliminated.

The combined efforts of the Rocket Design Group, Quality Department, and Reliability Control Group have resulted in design improvements and establishment of more definite assembly procedures. Particularly with respect to the torquing, installing, and clamping of lines, more uniform assembly and inspection procedures were established. This considerably reduced the number of discrepancies on the last six engines of the vibration acceptance test program.

The majority of failures on the last six engines were nonrepetitive and were attributed to human errors. A significant decrease in human-error failures has been obtained by providing better instructions for engine assembly, by training personnel, and by enforcing inspection procedures stringently.

7. RASCAL RELIABILITY EDUCATIONAL PROGRAM

The first portion of the Rascal Reliability Educational Program was completed early in July 1956. This consisted of 144 forty-five-minute sessions, each of which included a showing of the first Rascal Reliability educational film and talks by members of management. Nearly 2600 employees of the Manufacturing Division at the Niagara Falls and Wheatfield plants attended these sessions.

An evaluation of the effectiveness of the program has shown that the movie and talks were informative, interesting, and served a useful purpose. The program seemed to stimulate production workers and point out the important part each must play if the reliability program is to be a continuing success. The increased interest taken by production workers in their jobs was visibly noticed by supervision.

The second educational presentation will be entirely on film and is currently being completed. Presentation of this film to employees is scheduled for early in October 1956.

D. GAM-63 Missile

1 airframe

A. SYNOPSIS

The aerodynamic work on the GAM-63 has essentially been completed. The results of this work, consisting of both theoretical and experimental analyses, have been published in the following Bell Aircraft reports:

Report No.	Title
D98-945-035	Rascal Design Proposal
56-978-003	Basic Aerodynamic Characteristics of the XB-63
56-978-010	A General Study of the Performance Capabilities of the XB-63
56-978-011	Static Stability, Control, and Maneuverability of the XB-63
56-978-012	Dynamic Stability, Control, and Maneuverability of the B-63
56-978-013	Aerodynamic Heating and Thermal Analysis of the XB-63

The GAM-63 missile has an over-all length of 32 feet, a maximum body diameter of 4 feet and a gross weight of approximately 18,500 pounds. Structurally the airframe consists of five major sections: the radome, forward body, warhead section, center tank section, and aft body (see Figure 6). These divisions are based upon functional requirements as well as component accessibility and ease of shipment. The structural components of the Rascal missile are shown in Figure 7.

The radome, a laminated ogive, encloses the unattended search radar antenna and is attached to the forward body by means of a splice ring. The forward body section includes the rudders, the forward wing and elevators, and houses guidance and servo units. Two large structural doors provide access to the upper compartment of the forward body. The lower compartment is accessible by removing the lower door of the warhead section.

The warhead section consists of a fixed upper half-shell which is a removable structural door to facilitate

Figure 6. Cut-Away View of Rascal Missile

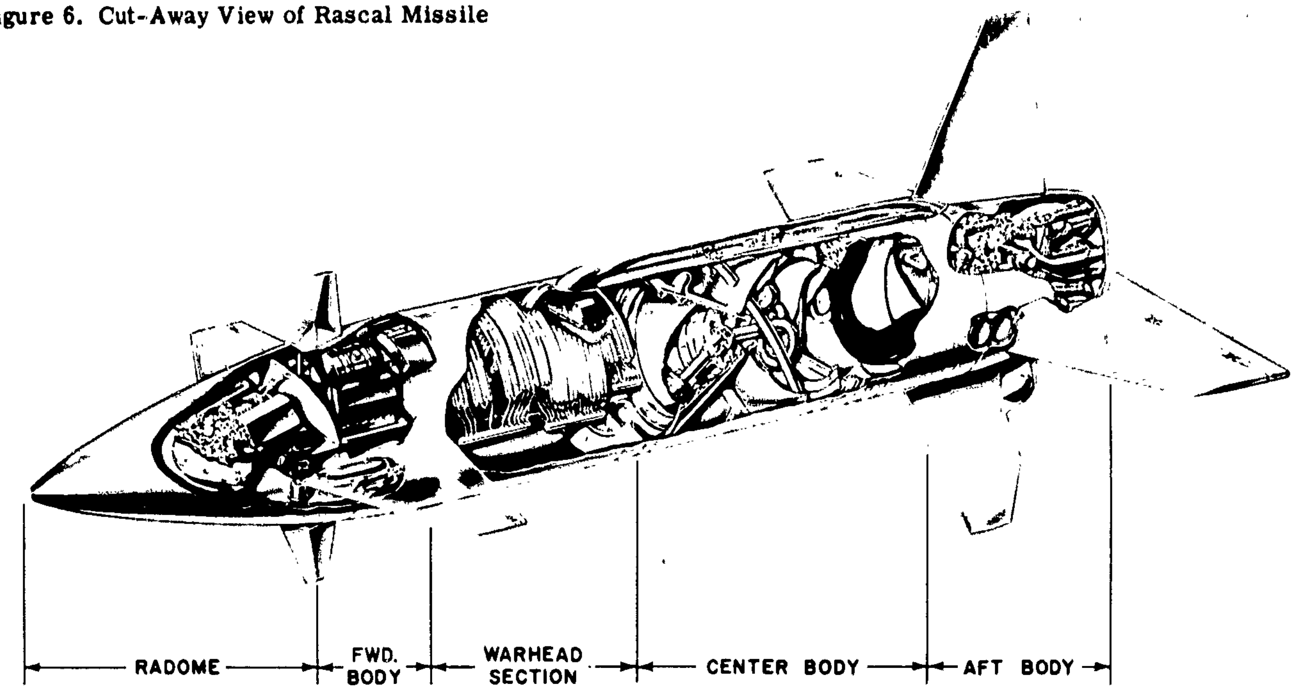
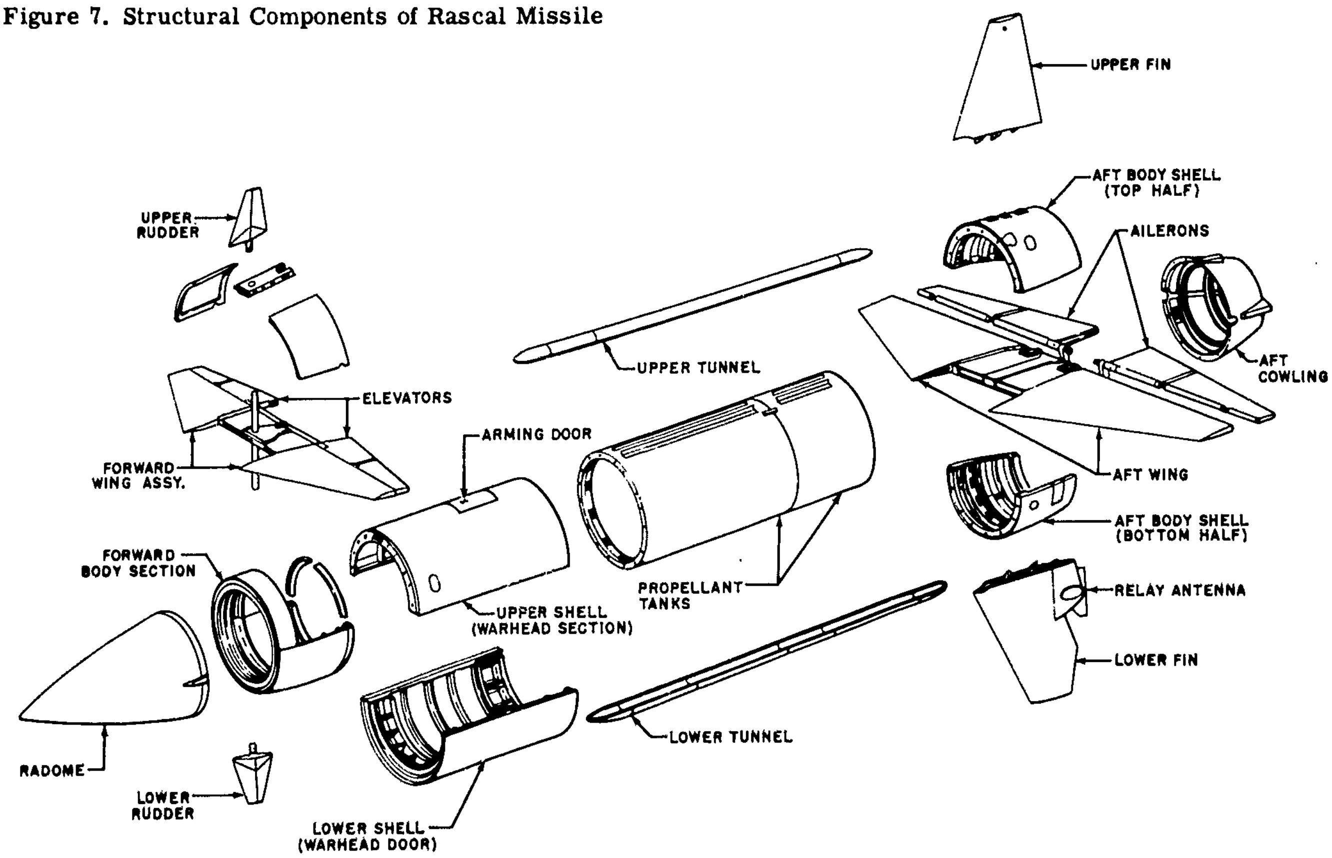


Figure 7. Structural Components of Rascal Missile



installation of the warhead. A small access door is provided at the top centerline of the upper shell for arming the warhead.

The center body section is a ring-stiffened cylindrical shell of aluminum alloy with integral oxidizer and fuel tanks compartmented to maintain center-of-gravity control. Nonstructural tunnels running fore and aft on top and bottom of the body enclose electrical cordages as well as propellant, nitrogen, and hydraulic lines.

The aft body section includes the vertical and horizontal tail surfaces, equipment compartment, rocket engine, and aft cowling. The rocket engine is mounted on a truss attached to, and supported by, the carry-through structure of the aft horizontal wing.

Launching provisions consist of two forged steel fittings used to attach the GAM-63 to the director aircraft by means of shackle-type hooks. One fitting is located at the forward end of the warhead section, and the other is located in the center body between the propellant tanks.

B. STUDY PROGRAMS

1. GAM-63 Radome

The investigation of rain-erosion protection of the Rascal radome is nearly complete. Studies thus far have considered (1) protective coatings, (2) new radome materials, and (3) dispersion of rain drops by employing a nose-probe deflector.

Results of the investigation indicate that the present radome coating used on Rascal, an air-drying neoprene base, possesses the greatest erosion resistance of nonmetallic materials.

Research programs are being conducted by Convair and by Cornell Aeronautical Laboratories under other USAF contracts to evaluate radome materials and coatings for several speed ranges and simulated rainfalls. Bell Aircraft has recommended and discussed with the WSPO minor extensions to these programs so that the test results will be applicable to the GAM-63.

Relative to the use of a nose-probe for dispersion of raindrops, the investigation indicates that tests and further complementary analyses are required.

Results of the radome study are being compiled in a report which summarizes the approaches to the problem, recommendations for additional analysis and tests, and the conclusion that the present GAM-63 radome coating is the most suitable material available.

2. Low-Viscosity Hydraulic Fluid Investigation

The program of evaluating XF 4270 silicone hydraulic fluid for use in the Rascal hydraulic system is scheduled to be completed in November 1956. Use of this low-viscosity hydraulic fluid may obviate the need for various provisions on the missile to maintain the oil heated during the prelaunch phase.

Following the initial phases of the lubricity evaluation tests, examination of pump parts indicated no appreciable wear. The final phase of the study now under way comprises a series of long-duration pump runs (tests-to-failure) to determine the lubricatity characteristics of the fluid.

3. Redesigned GAM-63 Destructor System

At the request of the WSPO, a design study was conducted in an effort to eliminate the present primacord destruct charge and to provide a different means of separating the missile.

A preliminary proposal for the redesigned destructor system was submitted to the WSPO for review in August 1956.

The new system involves (1) special bolts with explosive nuts for joining the aft body to the tank section, (2) a guillotine for interrupting the 28-volt, a-c power supply to the rocket engine, and (3) raising the energy level to approximately 6 amps for firing each ballistic component. Evaluation of aerodynamic and inertial loads indicates that positive separation will take place under all flight conditions. A final engineering proposal is being prepared for submittal to the WSPO early in the next quarter.

4. Simplification of the Electrical System

Components of the GAM-63 electrical system are being studied to simplify circuitry and reduce their size. A new transformer-rectifier that is one-half the size and weight of the present unit has been tested successfully. Additional miniaturized components are on order and will be tested when delivered.

A permanent-magnet-type a-c generator is being considered for the GAM-63 electrical system. The absence of commutator and brushes, and improved voltage regulation characteristics, make this generator particularly suited for high-altitude opera-

tion. Evaluation tests will begin after the generator is received from the vendor.

Additional work includes an investigation to provide maximum wiring simplification of the main interconnecting box. Test results indicate that the use of ferromagnetic plastic tape as a magnetic shield for Rascal wiring is not practical.

C. SPECIFIC SYSTEM IMPROVEMENTS

1. Dual Warhead Capability

At the request of the WSPO, the requirement of a dual warhead capability for the Rascal missile will be removed from the program. This dual capability was to be effective on missile No. 87 and subsequent.

Design work for the dual warhead capability was completed during the second quarter of 1956. Major structural changes were accomplished on the warhead door and electrical installations were under way. Current work is aimed at removing the capability, and, from a structural standpoint, this will be accomplished on missile No. 87 (the same airframe on which the capability was to begin). Changes in the electrical installations, reverting back to the single warhead capability, will be completed on missile No. 90.

2. Boattail and Aft Wing Redesign

In a effort to decrease drag and increase performance, the aft boattail and aft wing of the missile are being redesigned. The new boattail (shell and covering) extends aft of the fuel tank and is circular in cross-section. The redesigned aft wing features a 4% root section and a 2.7% tip section as compared with the 6% root and 4% tip of the present wing; the planform remains the same.

Although design and analysis are essentially complete, additional work is contemplated to ensure compatibility of the new designs.

3. Fin-Fold Redesign

The lower fin of the GAM-63 folds sideways 103° from its fully extended position to provide ground clearance when the missile is attached to the pylon of the DB-47. The fin is extended after take-off. The fin-fold redesign incorporates changes to increase reliability and to simplify the system.

During this quarter, a Development Exhibit covering the redesigned fin-fold system was submitted to the WSPO for approval.

D. FLUTTER ANALYSIS

Studies comparing computed with test modes and frequencies of the aft horizontal surface and the rudder have been completed. Reports are being prepared to summarize the results of these studies.

Dynamic characteristics of the Rascal airframe in the pitch and roll planes are being determined experimentally by feeding an oscillating electrical signal into the demodulators of the autopilot and recording structural response from several points on the airframe. Experimental results will be used to confirm the zero airspeed-structural response of the airframe that was calculated in the servo-flutter analyses. In addition, the structural as well as the servo characteristics will be used to investigate analytically the stability of the servo system both on the ground and during flight. Since this program is providing experimental data concerning the servo-airframe system, the flutter analyses involving the servo system have been delayed until the experimental data are evaluated.

As mentioned in previous Quarterly Progress Reports, the free play of the control surfaces of a series of GAM-63's is being measured upon completion of manufacturing and again just prior to flight testing. These measurements are being made to determine the free play resulting from ground-testing the missile and to determine indirectly the effects of known amounts of free play on the flutter stability of the GAM-63 during flight. Thus far, data are insufficient to draw conclusions concerning the effects of ground-testing on free play. An examination of data from the flight of missile No. 4176, the third GAM-63 flown with known free play, gave no indication of detrimental effects to the flight as a result of free play. Based upon measurements taken immediatly prior to the flight, the control surfaces exhibited amounts of free play that generally exceeded the maximum set forth in Deviation Paragraph A-17 of Specification 66-967-011.

As recommended by the Dynamics Branch of WADC, a test was conducted to measure the deflections of the control surfaces of a missile (airframe No. 46) due to known applied loads. Objectives of this test were to obtain free play and elasticity of the control surfaces and to check the procedures that are currently used to make free play measurements. The free play measured during the test compared well with that obtained using the current procedure. However, several methods of improving and simplifying the existing procedure are being studied.

2 propulsion system

A. SYNOPSIS

The GAM-63 is powered by a liquid-propellant rocket power plant incorporating a turbine pump drive unit. The thrust required to propel the missile to supersonic speed is provided by three identical chambers that develop 12,000 pounds thrust at an altitude of 40,000 feet. The liquid propellants are pumped to the thrust chambers by a gas-driven turbine pump which also furnishes auxiliary power to drive the hydraulic pump and alternator through suitable take-off pads. The turbine pump, utilizing the same propellants as the rocket engine, may be operated independently of the thrust chambers by passing the pumped propellants back to the tanks; this furnishes the required electric and hydraulic power during periods when thrust chamber operation is not required.

The propellants, JP-4 jet fuel and white fuming nitric acid (WFNA) oxidizer, are contained in tanks that are integral parts of the airframe. The oxidizer tanks, fabricated from stainless steel for missiles through No. 4277, are fabricated from Type 6061 aluminum alloy starting with missile No. 79. Type 6061 aluminum alloy fuel tanks, having passed the vibration testing program, were installed in missiles Nos. 4176 and 4277. Incorporated in the aluminum fuel tank is also the conversion to a bladder-type expulsion system. Whether or not the bladder-type expulsion system will be used in the oxidizer tanks depends upon the outcome of an investigation to determine the compatibility of the bladder materials with inhibited white fuming nitric acid (IWFNA). Tank pressurization and valve actuation is accomplished by use of nitrogen gas, under high pressure, stored in tube bundles conforming with the inner circumference of the missile. The oxidizer WFNA was used for the YLR-67-BA-1 and -5 engines and IWFNA for the YLR-67-BA-9 engines. The addition of hydrofluoric acid to WFNA has reduced the rate of corrosion in the entire propulsion system and has resulted in holding the oxidizer within specifications for a considerably increased length of time during storage in the missile.

When the launching method was changed from a powered launch to free-fall launch, the protection of personnel in the director aircraft was no longer a factor; thus, most of the safety system formerly used became unnecessary except during ground firings. As a result, the safety system was modified so that only turbine pump operation is monitored during the prelaunch period, up to the time the rocket-fire signal is given.

Missiles Nos. 4176 and 4277, employing the YLR-67-BA-9 rocket engine, were flight-tested at Holloman Air Development Center during this quarter. Test records indicate satisfactory power plant performance for missile No. 4176 for the full-duration of the flight. Missile No. 4277 maintained satisfactory power plant operation until the time of destruct. The primary flight test objective of No. 4277 was to evaluate the -9 rocket engine with the Bell-designed turbine pump.

B. SPECIFIC PRODUCT IMPROVEMENT

1. Rocket Engines

In the course of developing a rocket engine suitable for qualification testing and subsequent production, several engine designs were tested and approved. The YLR-67-BA-1 and -5 designs, approved for use during the initial phases of the GAM-63 flight test program, were used in missiles Nos. 0104 through 3964. The YLR-67-BA-9 engine, superseding the former models has completed the Preliminary Flight Rating Test (formerly called Flight Approval Test) and the test reports have been approved by the Air Force. The -9 engine is employed on all flight test missiles including those for the EAST program.

During this quarter the WSPO approved the continuation of the engine development program utilizing IRFNA as the oxidizer in place of IWFNA. An engine design, utilizing IRFNA and incorporating a dual fly-ball-governor speed control, has been fabricated and given the designation YLR-67-BA-11. Model specifications for this engine have been written and submitted to the WSPO for approval, together with details for a Preliminary Flight Rating Test program. The -11 engine has essentially completed development tests similar to the Preliminary Flight Rating Tests required by the Air Force. The Preliminary Flight Rating Test Program for this engine and its components is scheduled for the next quarter.

An advanced configuration of the YLR-67-BA-11 engine has been designated the LR-67-BA-11; model specifications and details of qualification tests have been submitted to the WSPO for approval. Qualification testing of the -11 engine is scheduled for completion during the first half of 1957.

2. Thrust Chamber Assembly

a. Tubular Thrust Chamber Testing Program

During this quarter, 14 thrust chambers for YLR-67-BA-9 rocket engines were satisfactorily ac-

ceptance-tested. One chamber, rejected because of low performance, was subsequently refired and the results indicate satisfactory performance. An investigation of the discrepancy is under way.

The occurrence of cast-aluminum tubular thrust chambers with small throat areas has increased considerably. Quality checks are in progress to determine exactly where in the manufacturing process the throat shrinkage occurs. Because the matching of a thrust chamber of small throat area with a propellant pump of constant weight flow will cause the chamber pressure to rise up to 110% of rated pressure, a series of tests was initiated to investigate the durability of the thrust chamber under these conditions. So that these tests may closely simulate actual operating conditions, all between-run servicing conforms with field test procedure. The first two thrust chambers failed after five 160-second runs owing to excess leakage of oxidizer through the coolant tubes. A metallurgical examination of the failed tubes of the first chamber has revealed no abnormalities. The second chamber is being sectioned for examination. A third chamber is being fired under the same conditions to confirm these results. In addition, to establish a chamber pressure/service life relationship, a fourth chamber will be fired at low chamber pressures (450 psig).

Casting of the two remaining copper brazed tube bundles which were chrome-nickel plated during the last quarter has been completed. It is anticipated that plating the tubes will increase the resistance to erosion by the hot gases and will help to prevent burnouts caused by gas leakage between the tubes.

b. Drilled Aluminum Thrust Chamber Testing Program

Three drilled aluminum thrust chambers were fired during this quarter. Two chambers, used to evaluate experimental injector configurations, are discussed in Section B, 3, of this report. The third chamber was utilized to evaluate a flame-plated tungsten carbide coating obtained from the Flame Plating Division, Linde Air Products Company, Speedway, Indiana. In all, 14 runs totaling 510 seconds were made prior to failure of the uncoated portion of the chamber. The coating was in excellent condition following the run series. The injector used for these tests had previously severely grooved several hardkoted chambers (see Figures 8 and 9). Because of the promising potential of this coating, a drilled aluminum thrust chamber with the entire chamber section coated with tungsten carbide is being fabricated. Also, an additional chamber is being coated with a new type of tungsten carbide recently developed by Linde. This coating contains a chrome-nickel binder in place of cobalt and may be even more suitable for thrust chamber applications.

Figure 8. Comparison of Erosion in Coated and Uncoated Thrust Chambers

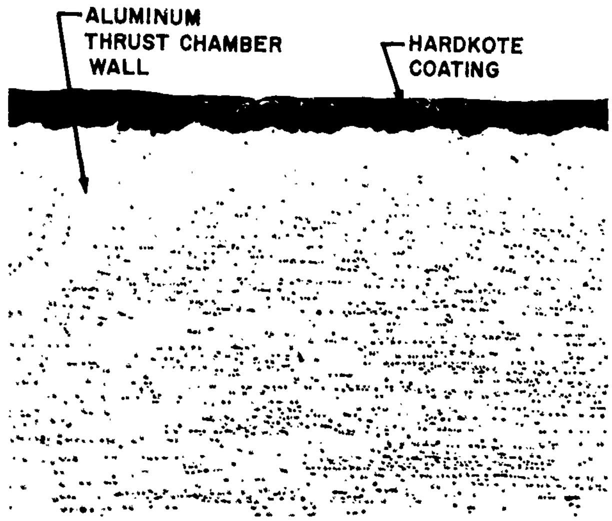


Figure 9. Micrograph of Aluminum Thrust Chamber Showing Hardkote Layer

Shown in Figure 8 are sections of two drilled aluminum thrust chambers fired with injector R397.

The chamber on the right had a 3-inch coating of 0.004-tick tungsten carbide at the injector end. Presented in Figure 9 is a photomicrograph of the tungsten carbide coating following fire test.

c. Refractory Coatings

Experiments with the equipment for spray-coating alumina and zirconia by the Armour Process indicate that the equipment requires further development. Coatings applied were not adherent and were nonuniform. Discussion of the problems is planned with Continental Coatings Corporation, the licensor of the equipment.

d. Redesign Thermal Relief Valve

Development work has been completed on a redesigned thermal relief valve for the hydrazine packs. The new valve differs from the previous design in that it does not require propellant valve actuation pressure for sequencing and is contained integrally within the hydrazine pack. This simplifies missile plumbing and eliminates a gas pocket in the actuation circuit which was difficult to bleed. The redesigned unit is basically a low-pressure relief valve in series with a normally open pressure-sequenced (requiring differential pressure to close) valve. Thus, during stand-by conditions, a relief valve is available which is power-closed before the fuel pressure rises to rated value within the hydrazine pack. This valve is undergoing engine tests. Previous bence tests indicate satisfactory valve performance at temperature extremes.

e. Redesign Fuel Injector Valve

Service life testing of the redesigned fuel injector valve on a thrust chamber has been completed. After 58 runs, leakage past the valve seat (teflon) was reported. Other than leakage, valve performance was satisfactory and duplicates all operating characteristics of the "O" ring seat valve. Upon disassembly of the redesigned valve, the seat appeared damaged and chipped; this was apparently due to the presence of foreign matter on the seat at the time the valve closed. The unit is undergoing engine tests. Approximately 81 hot firings have been conducted on this type of valve.

3. Injectors

Fifteen production injectors for 75 L* thrust chamber assemblies were tested and accepted during this quarter. To date, 230 injectors of this configuration have been completed. In addition, six test units of the same configuration were tested and found to be acceptable for assembly on test engines.

No additional fuel dome cracks have been noted during durability studies of the stainless steel 75 L* injectors. Monitoring of runs will continue for study purposes.

Experimental testing during this quarter was primarily directed toward endurance testing of drilled aluminum thrust chambers. The RM injector, which previously operated for nearly twice the required duration on the drilled aluminum chamber, was tested to obtain data on "O" ring joint leakage. In the duration series, the thrust chamber had been dissembled for examination and evaluation after a maximum of four concurrent runs. Some "O" ring burning was noted after these runs. This burning and/or leakage of the "O" ring is due to the slight thermal distortion of the injector on extended duration tests. The injector distortion is greatest on new injectors and a permanent "set" takes place after a number of runs. Because of this distortion, it was desirable to replace the "O" ring seal after each run, particularly on new equipment. Since the permanance of the thrust chamber assembly is questionable, studies are being made to determine a more permanent type of seal; however, tests have not yet been made.

Owing to the distortion problem when using a steel injector, and because of the desirability of an all-welded unit, aluminum injectors of the RM configuration have been test-fired in the drilled chambers. An aluminum injector (R-524) of the RM configuration, but having doublet oxidizer orifices replacing the "fuzzed" holes of the RM injector, was reported in the previous quarter to have completed twelve 195-second runs in a drilled aluminum chamber. This injector was modified to incorporate slightly different exit conditions on the impinging doublets to eliminate face erosion. Although the modifications were effective in eliminating erosion in the immediate vicinity of the orifices, it was not considered that the general erosion was effected, and that further modifications were needed.

The second "doublet" injector (R-553, which is the same as R-524) was welded into a drilled aluminum chamber and test firings were made using IRFNA and JP-4 as propellants. This assembly was tested during eleven 195-second runs without damage to the thrust chamber; however, the injector erosion was substantially greater than with the R-524 and eventually resulted in a drop-off in performance of approximately 3.5%. This difference in injector erosion has not yet been fully explained.

The third doublet-type injector was changed to incorporate a modified propellant distribution across the injector face. In addition, an Alumilite Hardkote surface was incorporated on the face of the injector.

Four full-duration runs were made on this injector in a drilled aluminum chamber without erosion on the injector face. These runs were made using IRFNA and JP-4 as propellants. A slight erosion of the thrust chamber resulted, but well within the tolerance limits for full-duration requirements. Performance of this thrust chamber was approximately 4920 ft/sec characteristic velocity and a specific impulse of 221 seconds at the start of the run. Some drop-off in performance was noted throughout the runs. Additional tests will be made on this unit.

A standard 75 L* stainless steel injector (R-397) was tested in a tungsten carbide coated chamber. An excellent correlation of the effects of the flame plating was noted because only the upper portion of the chamber was plated. Typical grooving of the chamber occurred below the flame plating and the upper portion of the chamber was untouched. Owing to the promising effects of this coating, two aluminum injector blanks will be coated to test the effect on the injector face. Drilling samples have been made and the coating can be penetrated with excellent results with the Elox electrical discharge machine.

A stainless steel showerhead injector was also tested; however, because of the high face temperatures involved, an injector chamber seal was not maintained and no regenerative data were taken. Two modified aluminum showerhead injectors were completed and will be tested early in the next quarter.

4. Rocket Engine Flushing Procedures

Considerable effort has been directed toward finding a liquid (other than water) that is compatible with fuming nitric acid and is capable of dissolving the corrosion salts of the acid and metals. Since it is essential to remove the water, as well as the corrosion crystals, from the system to prevent possible malfunction at -33°F, additional tests were made to substantiate the "tri-liquid flush" system (water/alcohol/methylene chloride). For these tests, the most critical components in the gas generator were used, with corrosion salts being formed intentionally in these components. After using the tri-liquid flush system to remove the corrosion salts, the gas generator assembly was fired successfully at -33°F. Examination of propellant valves and pressure regulators after other flushing tests confirmed the complete removal of all corrosion salts and all traces of the three flushing liquids.

5. Turbine Pump Assembly

a. Turbine Pumps

Three additional turbine pump assemblies from the production assembly line were successfully acceptance-tested during this quarter.

The assembly of the first qualification-test turbine pump using the dual-flow fly-ball governor speed control system has been started. Two turbine pump drive assemblies for the flight rating dual-flow fly-ball governor pump are 95% complete.

b. Hypergolic Gas Generator

During the testing and acceptance of four gas generator packages, inconsistencies in the calibration levels of the liquid regulator outlet pressures, maximum cruise and boost manifold pressures, and power control valve operating position became apparent. Changes have been proposed to lower these regulator outlet pressures and maximum manifold pressures so as to allow the power control valve to take a more open operating position. Such changes will facilitate the acceptance of gas generator packages, turbine pump packages, and engine assemblies.

During the development testing of the governor-controlled gas generator package, it was determined that the gas generator would not run at a steady state total mixture ratio of 0.66, with IRFNA containing 3% water, at -33°F environmental temperature and 200 psia chamber pressure. This gas generator was designed to have a nominal 23% of the total fuel go through the primary injector. Several modifications were made to meet the prerequisites of reliable, stable performance in the YLR-67-BA-11 engine system.

The minimum operating chamber pressure has been established at not less than 225 psia. Theoretical considerations and development testing have revealed that this value is sufficiently lower than minimum power requirements to allow an adequate control range. The governors are to be adjusted to remain open below a minimum flow corresponding to 225 psia chamber pressure. The minimum steady state total mixture ratio is being considered as 0.68 or higher. Development testing has indicated that the mixture ratio control range required for a governor is small enough to permit using this value as the minimum.

The gas generator was redesigned to have a nominal 18% of the total fuel go through the primary injector. This was a major change to maintain the primary mixture ratio nearer stoichiometric mixture ratio while generating gas at the same original temperature. It has been established that the flameout total mixture ratio for a lean primary mixture ratio gas generator is lower than that for a rich primary mixture ratio gas generator. Table I of Quarterly Progress Report No. 44 shows that a lean primary mixture ratio gas generator will run on acid containing more water than will a rich primary mixture ratio gas generator.

A series of tests was made to determine the effect of watered IWFNA on gas generator flameouts. Results of these tests are summarized in Table III and illustrated in Figure 10. These runs fill in the gaps in earlier data obtained for the use limits program, described in Bell Aircraft Technical Data Report 56-982-041, "Interim Report on IWFNA Use Limits Investigation for the YLR-67-BA-9 Rocket Engine." This report recommends a use limit for water content as 80% of that percentage of water which just produces instability or flameout in a production gas generator at a mixture ratio of 0.66 and a temperature of -33°F. The tentative acid use limit, based on a conservative interpretation of these test results, was recommended as:

NO_2	- 2% maximum
H_2O	- 2.8% maximum
Total Solids	- 0.1%, or no visible solid suspended matter or sludge, whichever is lower
HNO_3	- balance

From Figure 10, it can be seen that the tolerable water content for the modified gas generator at mixture ratio 0.66 is 4.3, and 80% of this value is 3.4. If the modified gas generator tested during this subsequent program becomes a standard item, the use limits for water can be raised from 2.8 to 3.5% by weight, provided that further tests bear out the validity of results obtained with gas generator Serial No. HGP-81.

Work authorization has been obtained extending this program to include conditions not investigated during the period covered by the Interim Report.

Tests have also been authorized for preparing a use limits specification on IRFNA for the YLR-67-BA-11 engine.

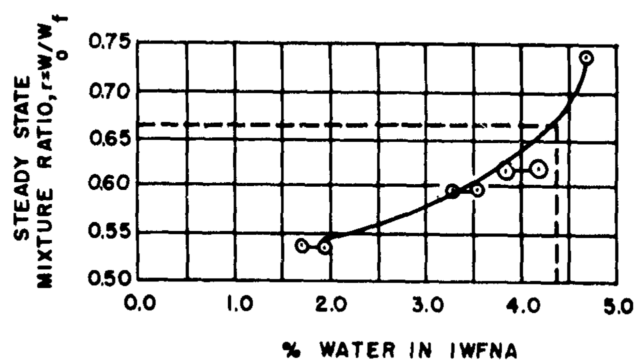


Figure 10. Limit of Steady State Operation at -33°F with Gas Generator HGP-81

According to plans mentioned in Quarterly Progress Report No. 44, an investigation was conducted to compare the carbon formation characteristics of a gas generator with a lean primary mixture ratio and a gas generator with rich primary mixture ratio. This investigation was to be completed from one common batch of fuel; however, two batches were used. Table IV compares the percentage of nozzle area clogging after 250 seconds in maximum boost phase for the two generator configurations at various comparable total mixture ratios. These values are averages of five individual tests per point. The table shows, for all practical purposes, that the percentage of clogging was approximately the same for each generator configuration.

The fuel flow sequencing valve was eliminated from the governor-controlled gas generator package. A modification to the gas generator was necessary to incorporate this change. The change was effected because (1) the -808 sequence valve would not stay open at the low chamber pressures encountered with the governor control system, (2) the

TABLE III

STEADY STATE LIMITS FOR A MODIFIED GAS GENERATOR

	Spec. Acid		Watered IWFNA					
Wt. % Water	1.7 - 1.9		3.2 - 3.5		3.8 - 4.2		4.67	
%Fuel Flow Thru Primary	19.0		16.9		15.3		20.8	
Propellant Temperatures	Mixture Ratio		Mixture Ratio		Mixture Ratio		Mixture Ratio	
	Steady	Transient	Steady	Transient	Steady	Transient	Steady	Transient
-35°F	0.541	--	0.599	--	0.613	0.679	0.737	0.659
					0.620	---		

TABLE IV

CARBON FORMATION TESTS

% of Total Fuel Going Through Primary Injector	Ave. Total Mixture Ratio	% Nozzle Area Clogging After 250 sec in Max. Boost Phase
17.4	0.588	2.92
17.4	0.699	12.12
17.4	0.781	11.96
* 22.9	0.591	1.22
23.0	0.716	11.24
* 22.9	0.785	12.80

* Runs made from second batch of fuel.

previous -602 sequence valve had a high malfunction probability, and (3) the integral sequence valve gas generator reacted sluggishly at low temperatures. Development testing revealed that satisfactory starts could be realized with no sequence valve. A typical start transient trace of gas generator chamber pressure, when no sequence valve is used, is shown in Figure 11. This chamber pressure is snubbed before it reaches the chamber pressure switch so that the initial pressure surge will not actuate the switch. A safety analysis of this system is under way. A large number of ambient and cold starts are being made to demonstrate reliability.

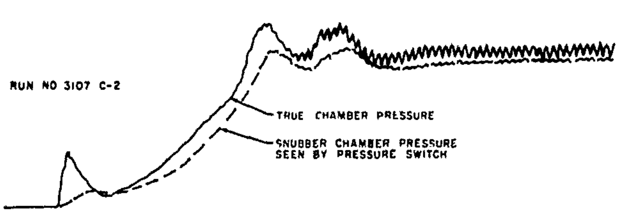


Figure 11. Gas Generator Start Transition (Typical P_c Trace Without Sequence Valve)

There have been no failures of gas generator propellant regulators as a result of galling or scoring on the diaphragm plate stem since the heavy chrome plated stems were installed in the regulators.

The single yoke gas generator propellant valve is undergoing tests on engines. The only reported difficulty with this valve to date is splitting of the lip seals. An investigation is under way to eliminate split seals while retaining the advantages (ease of assembly and reduction of "cold flow" difficulties) of this new seal configuration.

A reseat pressure of 200 psig for the integral sequence valve of the gas generator satisfies normal power requirements of the governor engine; however, during the start phase, chamber pressure dropped to a low value of 160 psig. A redesigned valve, offering lower reseat pressure while retaining the same opening pressure, was tested successfully at room temperature but exhibited sluggish opening characteristics at cold temperatures. This sluggish condition was apparently due to added friction of "O" rings (which are necessary in this design) at cold temperatures.

Subsequent to this, further development of the gas generator permitted successful starts without the use of a sequence valve. Additional development of sequence valves is being continued on a low-priority basis to provide a valve fully compatible with governor engine requirements. A throttling-type valve is currently being investigated.

C. DUAL-FLOW FLY-BALL GOVERNOR CONTROL

Eighty-seven runs, utilizing IRFNA were made on the turbine pump assemblies Nos. GP-6T, GP-7T, and GP-8T using the dual-flow (fuel and oxidizer metering) fly-ball governor speed control system to check performance and operation. Thirty-four of these runs were made at -35°F. The test results are discussed briefly in the following paragraphs.

One unit was assigned to a program of simulated qualification test requirements including ambient, high and low temperature duration runs. This unit malfunctioned at approximately one second on the first two attempted cold-temperature runs. Examination of data indicated an improper gas generator mixture ratio. The mixture ratio was corrected, and two successful runs were accomplished at -35°F. The simulated qualification test program was then completed with no other difficulties.

A stability test program was initiated to investigate performance and operation of the dual-flow governor pump at low temperature. The following are note-worthy points relative to this program:

(1) An orifice was installed in the line to the overspeed pressure switch to prevent malfunctioning at low temperatures. The switch was set at a higher pressure setting, but this has not yet been determined a permanent requirement.

(2) A Scheavitz position indicator was installed on the dual-flow governor to record the governor movement during the transition of start, from bypass to boost phase and vice versa.

(3) Repeated tests proved that the governor required a setting for a minimum flow, equivalent to a gas generator chamber pressure of 225 psia, in order to maintain combustion and prevent flame-outs of the gas generator.

(4) Runs made during this cold-temperature stability investigation have 20% of the fuel directed to the primary portion of the gas generator and the remaining 80% to the secondary portion of the gas generator.

(5) To establish a minimum gas generator mixture ratio, a ratio of 0.66 was arbitrarily selected. Several cold runs were unsuccessful with this mixture ratio and this indicated that 0.66 is too low. Additional runs are planned with a higher mixture ratio.

(6) An orificed line was installed bypassing the oxidizer side of the dual-flow governor. This bypass line was routed from the oxidizer start tank to the oxidizer discharge side of the dual-flow governor. Its purpose was to supplement the oxidizer supply during the start transient to eliminate flame-outs when running at cold temperatures with a gas generator mixture ratio of 0.66. Cold runs made in this configuration were inconclusive.

The initial time-interval setting in the sequence control unit Wilson Timer has been increased from $0.20^{+0.05}_{-0.00}$ to $0.25^{+0.05}_{-0.00}$ second. This change was necessary in the redesigned gas generator system to permit adequate start transient time to prevent a malfunction owing to the marginal time available for the gas generator chamber pressure switch to be actuated.

The first two sequence control units have successfully passed informal qualification tests at high and low temperatures and under vibration.

6. Propellant Tanks

An aluminum oxidizer tank passed qualification testing and fabrication is being concentrated on this design. The fuel tank previously passed qualification testing.

Tests have been performed to determine the effects on engine operation if the gas separator is removed. Test results are being analyzed and a report is being prepared. At entrained gas flow rates which adversely affect engine operation, the separator reduces the gas content of the liquid by 20%.

The first GAM-63 utilizing a fuel bladder tank has been flight-tested. The tank functioned satisfactorily after being loaded for 12-1/2 days prior to the flight test.

Orders were placed for three full-size Goodyear oxidizer expulsion bladders. The material for these bladders has withstood a soak and flexing test on a small-size bladder at 100°F for approximately two weeks. Tests have been conducted on samples of the material for resistance to acid at various temperatures, as well as for flexibility at low temperature. The resistance of the material to acid at elevated temperature is limited, but it has the best all-around characteristics of any material tested thus far.

7. Propellant Quality Control Program

In the Quality Control Program during this quarter, 325 samples of IWFNA were analyzed. An additional 310 samples from AF Plant No. 38 were analyzed for H_2O and NO_2 content.

Attempts to incorporate the use of a nitric acid analyzer into the program have been unsuccessful. Data on which the foregoing statement is based were shown to personnel from the WSPO and the following two decisions were reached. A series of samples of known composition will be prepared and used to construct calibration curves for IWFNA, and a similar

series of samples will be prepared and analyzed to obtain calibration curves for IRFNA. The latter are needed because of the changeover from IWFNA to IRFNA. In this regard, difficulties in obtaining a satisfactory method for NO_2 content analysis are anticipated.

The thorium nitrate procedure used at Bell Aircraft was evaluated by the WSPO and was found acceptable for use at HADC. Personnel at HADC can use this procedure or the more lengthy one called out in the USAF specification for fuming nitric acid. The latter, by mutual agreement, is accepted as the "referee method."

Two additional tests on a propulsion system using a YLR-67-BA-9 engine were conducted at AF Plant No. 38 to obtain further information on propellant stability and performance characteristics under desert storage conditions. During part of the first of these tests, the propulsion system was subjected to a temperature of 120°F for 12-hour periods. During the 28 days comprising the test, acid samples were taken periodically from the shotgun and various parts of the engine. The test was only partly successful because a pressure build-up occurred and led to venting of the oxidizer tank and acid spillage. Analyses of the acid samples showed that the acid met use limits throughout the test. If some acid is bled before collecting a sample for analysis, comparable results will be obtained for acid taken from the shotgun and the inlet line to boost No. 2 thrust chamber. Because of the convenience of taking samples from the latter position, this is recommended as a standard procedure. The actual changes in composition during test were:

	% NO_2	% H_2O	% HF	% Fe
2 July 1956	0.3	1.4	—	0.0001
1 August 1956	1.3	2.0	—	0.0001

Such results point up the efficiency of the corrosion inhibitor and the relative stability of the acid.

Test conditions were more severe in the second test. The oxidizer tank was vented and the pack was exposed to 120°F for approximately 14 of the 28 days. Results of this test will be included in the next Quarterly Progress Report. Preliminary data indicate that a slight, tolerable loss of HF occurred during heating. Water content remained within use limits but NO_2 content exceeded the limit of 2.0% by reaching a value of 2.2%. These results are for samples taken from the inlet line to boost No. 2 thrust chamber. Comparison with results from samples taken via the tank drains indicates that considerably more decomposition took place in the line than in the tank. As anticipated, the acid in the tank met use limits in all respects.

C. STUDY PROGRAMS

1. Expulsion Bladders

The third test-size Goodyear oxidizer bladder, approximately 15 inches long and 8 inches in diameter, of two-ply R2162-50 material with an outer coating of polyethylene-polyisobutylene, was tested in IRFNA at 100°F. After flexing at intervals for 19 days, the bladder developed two leaks at the seams. Except for seam leaks, condition of the bladder was satisfactory. Since the small-design bladders could not be made with lap-type seams, taped butt joint seams were used for the sake of expediency. The lap-type seams, as would be incorporated in a full-size bladder, will probably overcome the seam leak problem. After a discussion on design and fabrication with Goodyear, three full-size oxidizer test bladders were ordered; delivery is scheduled for early in the next quarter.

Two test-size oxidizer bladders made of improved Teflon film (Minnesota Mining & Mfg. Co.) are on order. Flex tests in IRFNA are planned.

Samples of alternate oxidizer bladder material, Kel-F elastomer on Teflon cloth, were received from Goodyear Tire & Rubber and from Chemical Rubber Products. Preliminary tests in IRFNA at 100°F indicate Goodyear material, No. 2162-71, is the most suitable of the samples submitted by this vendor. Although this bladder material failed in a cone pull-through test at -65°F, additional samples were requested for test at -65°F, additional samples were requested for test at -33°F. Samples received from Chemical Rubber Products are in test.

2. Detonability of Fuming Nitric Acid and Hydrocarbon Vapor Mixtures Diluted with Nitrogen

The detonation velocity and limits of detonability of WFNA/n-heptane vapor mixtures with up to 0.6 mole fraction of nitrogen were determined in the 1.5-inch-diameter, 10-foot-long reaction tube described in Quarterly Progress Reports Nos. 41 and 44. The reaction tube was modified to permit introduction of a metered amount of nitrogen. Detonation waves from equimolar mixtures of oxygen and acetylene were used to ignite the propellant/nitrogen mixtures.

Theoretical detonation velocities of these WFNA/n-heptane/nitrogen mixtures were calculated from thermochemical data and the Chapman-Jouguet theory relating detonation parameters. Comparisons between the theoretical velocities and the experimental velocities are presented graphically in Figures 12 and 13. Figure 12 presents a detonability envelope, bounded by the theoretical WFNA/n-heptane and the WFNA/n-heptane/0.6 mole fraction nitrogen curves. The shaded

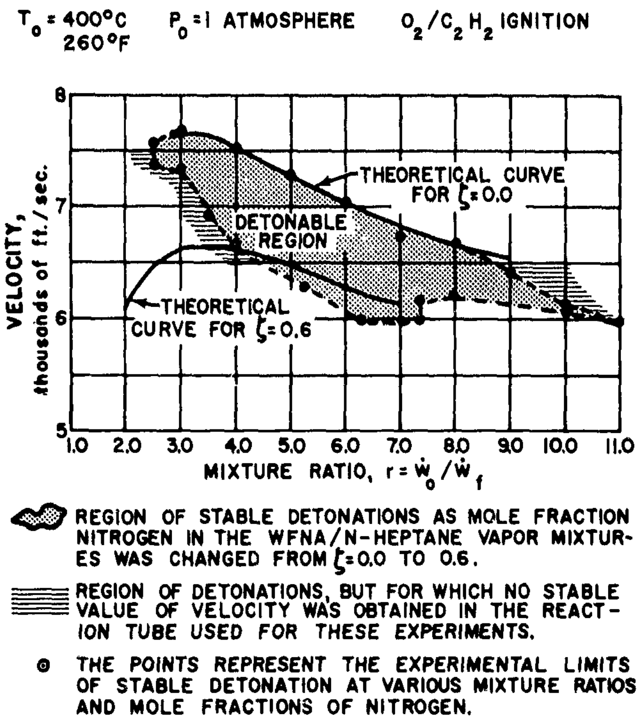


Figure 12. Detonability Region For WFNA/n – Heptane/Nitrogen Vapor Mixtures

areas at the lean and rich mixture ratio limits represent a region where detonations occurred but did not reach a stable velocity value in the length of the reaction tube used. No detonations were observed outside of this shaded region.

On disassembling the shock tube apparatus after a series of runs with WFNA and toluene, a residue was found in the inlet to the tube. Chemical analyses showed the residue to be p-nitrobenzoic acid contaminated with a small amount of a second material thought to be p-nitrobenzyl alcohol.

In an attempt to throw more light on this subject, WFNA and toluene vapors were passed through the tube at a mixture ratio of 4.0 and condensed. Preliminary work on the condensate has been done, but not enough to lead to any definite conclusions.

Fabrication of the new reaction tube, which will include a 22-inch x 1/8-inch axial slit, is progressing. The propellant evaporators, flow meters, flow control systems, and the heaters for this new tube have been built up in a new test area, where a greater safety margin for personnel can be provided during the higher initial pressure work planned. The new tube will be used to study the transition zone between deflagration and detonation in WFNA/hydrocarbon mixtures at initial pressures of up to 5 atmospheres. For this purpose, a Warricle strip camera will be used initially to photograph the slit.

Until the new tube is completed, the original reaction tube, which has been modified, will be used to study the detonation velocity and detonation limits of WFNA/hydrocarbon mixtures at initial pressure below atmospheric.

A paper, "The Detonability of Certain Rocket Propellants," which covered the initial stages of this work, was presented at the Sixth Symposium (International) on Combustion held at Yale University on 19 through 24 August 1956.

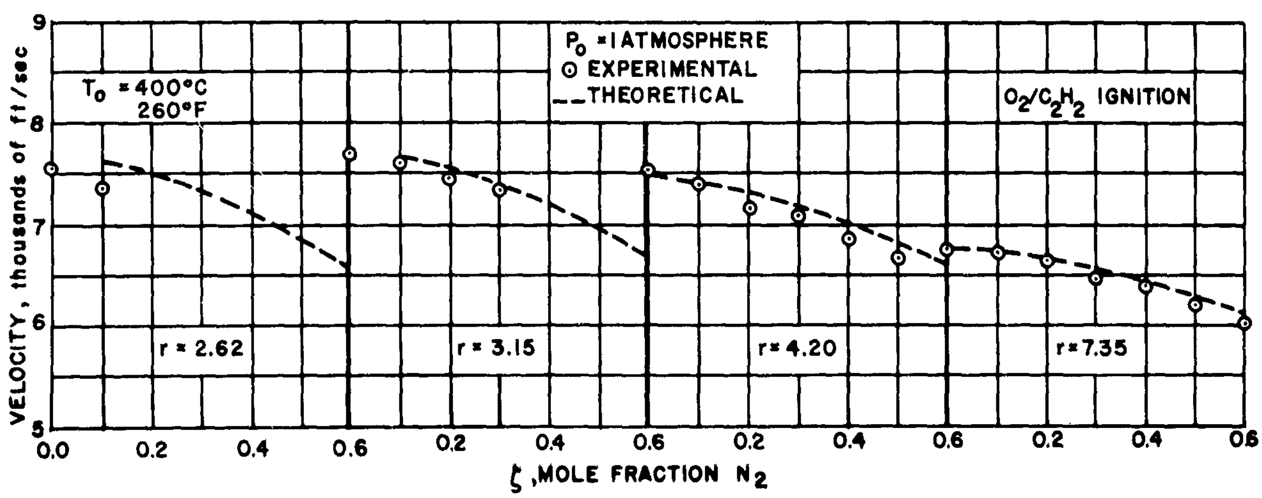


Figure 13. Detonability Velocity vs Mole Fraction Nitrogen for WFNA/n-Heptane/Nitrogen Vapor Mixtures

3. Acid Storage

During this quarter, each of the six drums of acid put in storage has been analyzed. These drums represent various types of fuming nitric acid in use/or being considered for use. One drum of WFNA from October 1955 was accidentally discarded. The original and final analyses are:

Two drums of RFNA, type IIIA, have been discarded because external corrosion to drum bungs made openings which permitted water to enter the drums and vitiate the tests. A drum of RFNA, type III, shows signs of water and sludge buildup. Unless drastic changes occur, it will be kept in storage unil November 1956. Another drum of RFNA, type IIIA, which originally contained an excess amount (19.21%) of NO_2, has undergone moderate changes and will also be kept in storage until November 1956. Storage of these four drums began in November 1954.

A drum of RFNA, type III, modified with BF_3 (0.4%), also put in storage in November 1954, showed little change in composition to November 1955. Again, external corrosion caused leakage and a sample taken in August 1956 showed an abnormal water content (12.8%). The test was therefore terminated.

The latter drum will be replaced with one of type III acid modified with ammonium hexafluophosphate. This compound added in sufficient a quantity to give a fluoride content of 0.3% shows excellent promise as a corrosion inhibitor.

Approximately 75 pounds of hydrated aluminum nitrate have been recovered from a badly corroded acid drum. The salt is available for future use limit testing.

4. Air Pressurization

Test cell space was not available during this quarter for further gas generator tests substituting air instead of nitrogen for pressurization and purge purposes.

5. Burner Studies.

A study of fuming nitric acid and hydrocarbon flames was initiated to determine flame speeds and sooting qualities simulating gas generator mixture ratios. A brief propane/air flame study program was carried out first to develop a photographic technique. The burning velocities at various propane/air ratios, calculated by the over-all area method, compared favorably with results reported by other investigators.

The apparatus required for the fuming nitric acid/hydrocarbon flame studies was fabricated and an acid flow rate calibration was made. The improved acid evaporator permits delivery of acid vapors having a 90 to 95% HNO_3 content to the burner. Direct and Schlieren photographs of acid/hydrocarbon flames will be made during the next quarter.

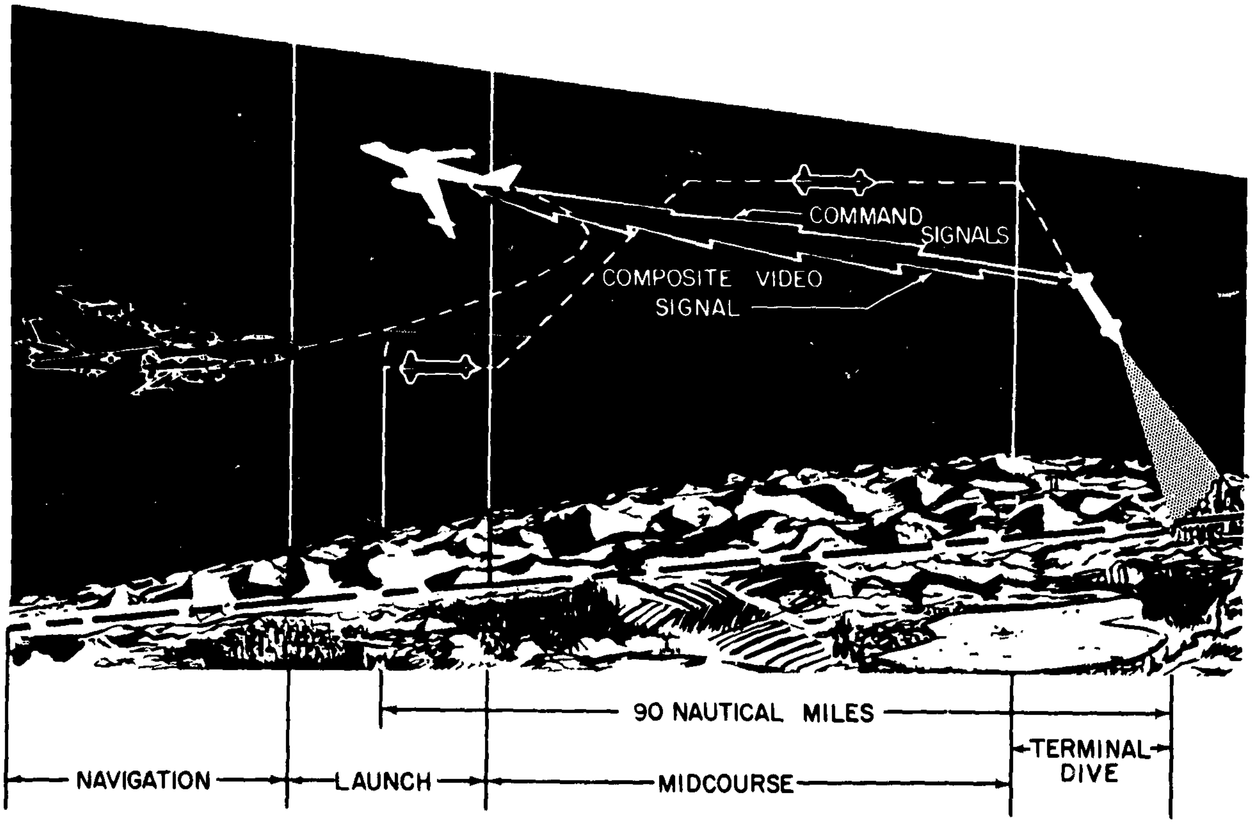
3 guidance system

A. SYNOPSIS

During the early stages of the Rascal guidance program, research and development efforts were directed toward a radar-relay and command guidance scheme for directing air-to-surface missiles to a target. In essence, this development was concerned with a radar scanning system housed in the nose of the missile by means of which a radar picture of the area ahead of the missile is relayed via a microwave link to the launching aircraft. On the basis of this video information, commands from the launching aircraft could be sent to the missile to direct it to the target. (The name RASCAL was coined from the first letters of the words RAdar SCAnning Link.)

At first, two B-17 aircraft were utilized in guidance development, one simulating the launching aircraft and the other the missile. Later, data from tests of this first experimental radar-relay and command link led to an improved guidance system which was installed in a B-17 and an F-80 aircraft to simulate more closely the guidance performance of a director aircraft and missile in flight.

Guidace for the Rascal Weapon System comprises an inertial range computer (IRC), an autopilot, and a radar-relay command link. Components of the command link are located both in the missile and in the director aircraft. Basically, the system operates as follows: The DB-47 director aircraft carrying the GAM-63 is navigated to the launch area by means of its modified bombing-navigation (MA-8) system which employs a long-range search/tracking radar and computers. Immediately prior to launch, initial condition data as computed by the MA-8 system (i.e., director



aircraft velocity and heading, and changes in range-to-target) are fed into the missile. After launch, the missiles IRC measures ground-range-to-target by double integration of a signal from a pitch-stabilized accelerometer. At a predetermined range from the target, the IRC initiates a signal which overrides the autopilot and places the missile in a preset terminal dive. By controlling the flightpath in this manner, the guidance and control systems establish a direct course to the point of detonation.

The search radar in the nose of the Rascal missile, a vital element of the relay and command link, is included to improve the accuracy of target acquisition. Just prior to terminal dive, the radar is turned on automatically by the inertial guidance system. This radar scans a 150° sector ahead of the missile, and radar video is relayed to the director aircraft. Here, the radar information, displayed on a PPI, enables the guidance operator to monitor the flight and to initiate course-correcting commands (both pitch and azimuth) which are transmitted via the microwave link to the missile. Should the guidance operator desire to observe the progress of the missile prior to terminal dive, a command can be transmitted to energize the search radar of the GAM-63. The operator can also control the initiation of the terminal dive.

A B-17 aircraft and a laboratory terminal guidance control station are being utilized to evaluate guidance improvements before incorporating them into the missile or the director aircraft. (The Rascal portion of the director aircraft guidance is referred to as the AN/APW-17 guidance system.) Also, missile guidance equipment is installed in an F-89 airplane to permit flight testing at altitudes and speeds simulating those of the GAM-63. This work is discussed in more detail in Section II, E, Support Aircraft.

B. EMANATING GUIDANCE

The progress reported here is for the missile equipment portion of the emanating guidance system. The status of development on director aircraft guidance (AN/APW-17) system is reported in Section II, E, Support Aircraft.

1. General

In the radar set and radio set, several cases involving subnormal performance of semi-conductor crystals and of small blower motors have been noted. The contributing factors are being studied in detail. Blower motors in stock are being returned to the vendor for rework of the bearings.

2. Radar Set

Improvements in automatic gain control have evolved and are being evaluated in the captive flight test program at Holloman Air Development Center. In addition, the practicability of providing a manual control of radar receiver gain for the guidance operator is being investigated.

3. Low-Power Antijam Radar Set

To provide a magnetron tuning rate of 300 mc/sec/sec, four model tuning motor and gear train assemblies have been built and are being evaluated. Performance has been generally satisfactory, but the type of motor may be changed to reduce the electrical noise generated.

Tests are in progress on a modified search radar antenna which provides a minimum band width of 300 mc.

An improved low-power load isolator has been obtained and tested in the low-power antijam system with satisfactory results.

4. High-Power Antijam Radar Set

Castings for the receiver-transmitter unit have been machined and impregnated, and a large percentage of the detailed parts have been installed. When this assembly work is complete, the unit will be evaluated in connection with a modulator. Additional sample tunable magnetrons have been ordered from Sylvania and are expected to be delivered soon.

Vibration tests on the 2022.1 cps crystal proved unsatisfactory. The vendor is designing new crystals which will offer no resonant points below 500 mc/sec.

Since the single-section pulse-forming network was not successful, a three-section network and associated magnetron pulse transfer were designed and tested. These tests proved satisfactory and this design will be used in future units.

A receiver with low noise level has been designed and fabricated. Although testing of the unit is still in progress, a decrease of 3 to 5 db in the noise figure is indicated.

5. Radio Set

As a result of efforts to locate a power-transmitting tube capable of improving the performance and reliability of the A1016 relay magnetron, detailed investigations are under way on the applicability of the QK553 carcinotron. This backward-wave tube has been developed by Raytheon primarily for airborne ECM application. Investigations have indicated that the QK553 is satisfactory for Rascal relay application, even though there are certain features of the Rascal requirements for which definitive QK553 test data are not yet available. Discussions are being held with Raytheon to set up a short-range tube application study program for determining the applicability of the QK553 tube to Rascal requirements.

During this quarter, RCA representatives conducted a tube-usage study on the A1016 magnetron at several Bell Aircraft test areas. A report is being prepared on the results of this study.

C. NONEMANATING GUIDANCE

1. Inertial Range-Computing (IRC) System

The IRC system measures range in a horizontal plane in the direction of the longitudinal axis of the missile. Directional control is maintained by the autopilot keeping the missile aligned to a gyro reference heading.

An accelerometer is orientated on the stable platform so that it senses accelerations along the longitudinal axis of the missile. The output is double-integrated and compared with the initial range-to-go value, thus giving an instantaneous range-to-go value. This output signal is compared with a preset voltage corresponding to the desired dive initiation point in the dive angle computer. Upon coincidence, a dive angle command is given to the pitch autopilot and a signal is sent to turn on the search radar in the nose of the missile.

Accurate information on range-to-go and velocity from the director aircraft navigation system is transmitted to the IRC system prior to launch. With this information, the platform is leveled and the necessary initial conditions are inserted into the system.

Evaluation tests are being conducted on the IRC components under extreme environmental conditions. Results of these tests indicate changes which can increase system reliability. Improved components are being incorporated in the present design.

Preliminary work is continuing on the combined repackaging of the three computers to be used in the IRC system. This redesign will provide improved assembly techniques, ease of testing and maintenance, and operational reliability under extreme environmental conditions.

2. Multiaxis Guidance System

Work on the multiaxis guidance system has been discontinued under the Rascal contract. This effort is now being conducted under Contract AF 33(600)-33242 and the progress achieved will be reported quarterly in a separate document (see Bell Aircraft Report 56-981-022-1, "Inertial Navigation System," dated 30 October 1956).

4 control system

A. SYNOPSIS

Following early design studies that included experience gained from the Shrike missile program, laboratory development of the autopilot system for the missile portion of the GAM-63 Weapon System was put on a full-scale basis in January 1951. In September of 1952, the first GAM-63 missile was delivered to HADC for flight testing.

The autopilot systems for the first GAM-63's were similar to that used in the Model 59 Shrike missiles. Design of the autopilot for subsequent GAM-63's, however, showed a significant increase in complexity when such capabilities as acceleration limiting, guidance loop tie-in, antenna stabilization, and altitude control were added. These features were included in the basic Model B and D configurations (missiles 11 through 35). The Model F configuration of subsequent missiles is further modified to accommodate the inertial range-computing system designed to meet the requirements of the weapon system.

With the development of this basic autopilot system, major emphasis has been shifted to the simplification of products and to the improvement of reliability and design characteristics. This program is proceeding satisfactorily. Concurrently with autopilot development, a series of terminal guidance control studies was conducted and this contributed significantly to the over-all design of the autopilot system.

The two main servo systems of the GAM-63 are the servopilot and the antenna stabilization systems. These systems utilize electronic amplifiers, an azimuth computer, potentiometers, hydraulic valves, actuators, a single-axis stabilized platform, and associated hydraulic plumbing and electrical wiring. The power supply is common to both systems.

The servopilot stabilizes the GAM-63 missile about its three axes: longitudinal (roll), lateral (pitch), and vertical (yaw). The roll system maintains the lateral axis of the missile horizontal throughout its flight. During portions of the flight, the pitch and yaw systems are programmed and receive guidance commands which direct the missile to the target.

The antenna stabilization systems perform three functions: (1) maintain the search antenna horizontal about the pitch axis with respect to the earth's horizon (since the search antenna is fixed to the roll-stabilized airframe, a separate antenna roll servo is not required); (2) maintain the rotating search antenna at a constant angular velocity in space; and (3) orient the relay antenna in pitch so that its major lobe is aimed toward the director aircraft.

B. FLIGHT CONTROL SYSTEM

The environmental re-evaluation program on the Rascal flight control system and the inertial range-computing system is continuing.

To date, 1112 environmental tests have been conducted on production models of electronic and hydraulic components. Of the 57 units undergoing tests, 21 units have successfully completed three cycles, 13 units have completed 2 cycles, and 11 units have completed one cycle. The remaining units are in various stages of test.

Development evaluation tests have been completed on three of the new directional gyros manufactured by the Kearfott Corporation. While these units are similar to the Kearfott production model T-2306 previously evaluated, they incorporate design improvements within the gyro, primarily in the caging mechanism. This new gyro has since been reidentified by the vendor as model T-2308-4A-A. A production order was placed with Kearfott to supply this gyro per Bell Aircraft Drawing 62-536-493 and Specification 56-947-507. The inability of the vendor to meet a delivery schedule has subsequently delayed incorporating the new gyro in the missile program. As presently planned, the unit will be installed in No. 95 and subsequent.

Further evaluation tests on a new Kearfott vertical gyro indicated that the unit was not acceptable for use in the Rascal program. Investigations are continuing in an effort to locate a more suitable vertical gyro.

Missile No. 46 is being utilized in the Servo Laboratory to investigate various mechanical coupling effects between the airframe and such pickoff elements as gyros and accelerometers. Also, this missile is being used to investigate such general problems as microphonic tube effects and electrical coupling.

Design improvements to eliminate resolution effects in the pitch control system and to provide a stable platform assembly capable of withstanding more severe vibrational environments were incorporated in missile No. 86 and subsequent.

An extensive program was conducted during this quarter in which production drawings and specifications for the flight control and inertial range-computing systems were brought up to date according to contractual requirements prior to submitting the documents to the WSPO.

The two-phase program for improving the reliability of the Rascal flight control system is continuing. Phase I of this program encompasses an immediate repackaging of six amplifiers in the system and a redesign of the power supply. Phase II, known as Flight Control System Redesign and Repackaging, involves those portions of the system in which the most significant reliability improvement could be realized.

In the Phase I effort, samples of design and workmanship on the part of Federal Telecommunication Laboratories (FTL) were displayed to Bell Aircraft personnel in July 1956 to exemplify progress made to date. Three units of the first set of prototype amplifiers have been received from the subcontractor and have been checked out functionally in missile No. 46. The pitch amplifier in both an assembled and a disassembled view is shown in Figure 14. Delivery of

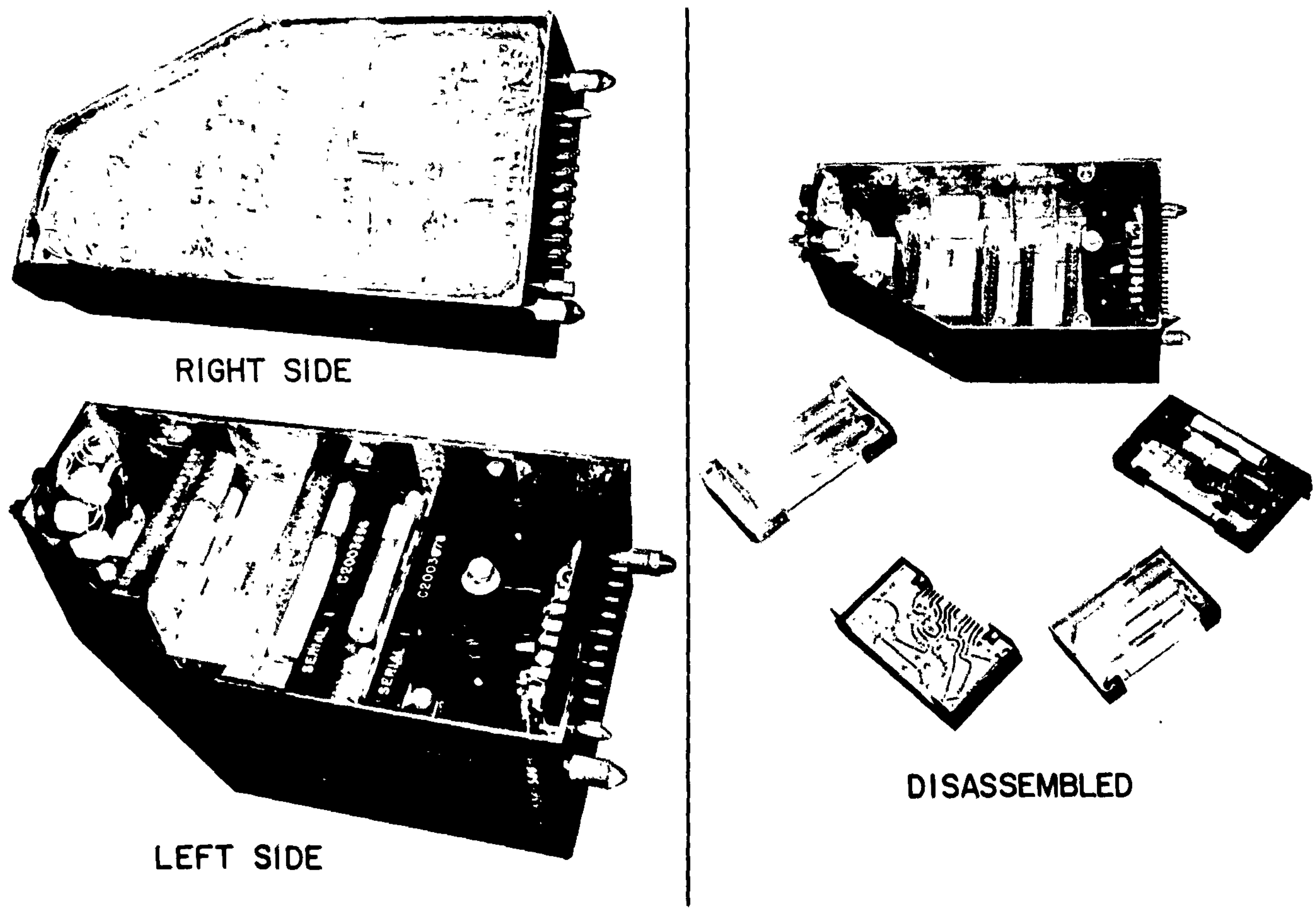


Figure 14. Repackaged Pitch Amplifier

the remaining three prototype units, plus an additional three units from the second set of prototypes, is expected in October 1956. Test equipment has been purchased by FTL to perform the repetitive reliability tests called for in the specifications. This equipment is being acceptance-tested prior to initiating the reliability test program during the next quarter.

The status of technical work on the Phase II effort is discussed in the following paragraphs.

Laboratory work has been completed on the pitch and yaw systems and a development report is being prepared.

As a result of a design review, the development report on the redesigned roll system is being clarified and expanded.

Hot and cold tests have been completed satisfactorily on the stable platform mechanical assembly. However, during vibration testing, difficulties were encountered with high transmissibility to the motor shaft and accelerometer; this problem is being investigated. Testing is continuing on the stabilization amplifier breadboard and the development report is being prepared.

Drawings for the relay antenna pitch controller are 98% released for test and the development report is being prepared. A prototype mechanical assembly has been completed except for electrical wiring and an electromagnetic clutch which is used to start the dive altitude programming. Problems have been encountered in the design of the clutch. Various plastics and metals were evaluated for consistency of coefficient of friction and wearing ability. This investigation is continuing on combinations of metals since plastics were unsatisfactory because of poor temperature characteristics or low coefficients of friction.

The first engineering model of the power supply for the control system was completed during this quarter and preliminary evaluation tests were started. Drawings for the power supply are approximately 80% complete and detail parts have been ordered for four engineering prototypes.

C. SERVO VALVES

Evaluation testing is continuing on the four basic types of double-nozzle, dry-first-stage servo valves for the Phase II effort. The spin-drive valve was subjected to system operation at room temperature and satisfactory results were obtained. Inspection tests are being performed on the other three types of servo valves used in the pitch, the roll and yaw, and the antenna stabilization systems. The units that were returned to the vendor have been reworked and are now acceptable.

D. HYDRAULICS

The search for a more reliable 10-micron filter for the hydraulic system is continuing. Evaluation tests are being performed on several purchased filters. A bubble pressure test has been used to determine the presence of large openings between the porous materials and the end caps of the filter elements. In this test, air pressure is applied internally to the filter element while submerged in hydraulic fluid to determine the pressure at which the first bubble appears from the element. This is also an ideal method of controlling maximum particle size and will improve the degree of filtration when equipment and test procedures are available in the production test facilities.

Concurrently with the immediate program to ensure reliable cylindrical accumulators (see MX-776 Quarterly Progress Report 56-981-021-45), another approach has been taken to procure or develop an accumulator which will operate at ambient temperatures as low as -65°F without the use of external heating. Evaluation tests are being conducted on sample accumulators from Bendix, Greer, Sprague, Weatherhead, and Redco. In addition, various nonstandard seal and gland designs are being tested in an effort to replace the familiar O-ring.

The present configuration of the hydraulic system employs a standard AN6203-1 spherical diaphragm-type accumulator (purchased from Vickers, Inc.) as a return-line surge chamber in the forward section of the missile. Although no service failures have been experienced with the accumulator to date, component qualification and evaluation testing per MIL-A-5498B, as well as hydraulic system testing, has resulted in numerous malfunctions. These failures usually resulted in the loss of gas charge internally. Examination of defective parts revealed that the diaphragm was fractured at the neck of the sealing bulb. The exact cause for this failure has not yet been established and cannot be isolated to cold temperature operation. Fatigue tests on a two-inch section of a diaphragm that had failed after 2000 hydraulically actuated cycles in a surge chamber began showing indications of failure only after completion of an additional 200,000 cycles.

Laboratory tests performed on the hydraulic system mock-up, incorporating a 50-cubic-inch cylindrical accumulator with heated end caps in place of the AN6203-1 spherical accumulator, were favorable. Under identical conditions, the pressure peaks experienced in the return line of the hydraulic system were within 100 psi for the two types of surge chambers. This replacement is being considered for incorporation in the missile program.

5 warhead and fuzing system

A. SYNOPSIS

The armament system of the GAM-63 must undergo extensive testing to achieve weapon status. Sufficient test planning is included in the over-all development program to ensure proper functioning and to obtain ultimately a high degree of accuracy and reliability for the warhead and its fuzing system. At the direction of WADC, work on secondary warheads was discontinued some months ago. Armament system specification, No. 56-947-377, was released after references to secondary warheads were deleted.

B. WARHEAD

The GAM-63 is designed to accommodate a 2800-pound special warhead. The warhead is located within the Rascal missile between the forward wing and the oxidizer tank (see Figure 15). The lower part of the airframe at this location serves as a structural door for warhead installation. Another door, approximately 14 inches square, at the top centerline of the airframe, provides access for arming the warhead. The warhead compartment is essentially cylindrical, with a maximum diameter of 44 inches and an over-all length of 75 inches.

A demonstration of loading a simulated warhead into a Model 56F (prototype operational airframe) missile was held late in 1954 at Bell Aircraft's Wheatfield facility. No major difficulties were encountered. The warhead cleared the missile structure and equipment installations satisfactorily. This demonstration was witnessed by personnel of both the Air Force Special Weapons Center and the Sandia Corpoation.

Early in 1955, it was determined during tests at Holloman Air Development Center that no electrical or electronic interference exists between the warhead and its instrumentation, and the other systems of the missile.

Simulated warheads have been tested in six GAM-63's. Operation of the warhead system in missiles Nos. 3044, 3441, 3643, and 3748 was considered successful by the Sandia Corporation.

The design for dual warhead capability has been completed. However, at the request of the WSPO, the capability will be deleted. The warhead compartment mock-up was modified and shipped to Sandia during the previous quarter for a formal mock-up review, and the fuzing system was redesigned to make it compatible with both the primary and the alternate warheads. Work is under way to remove the dual cap-

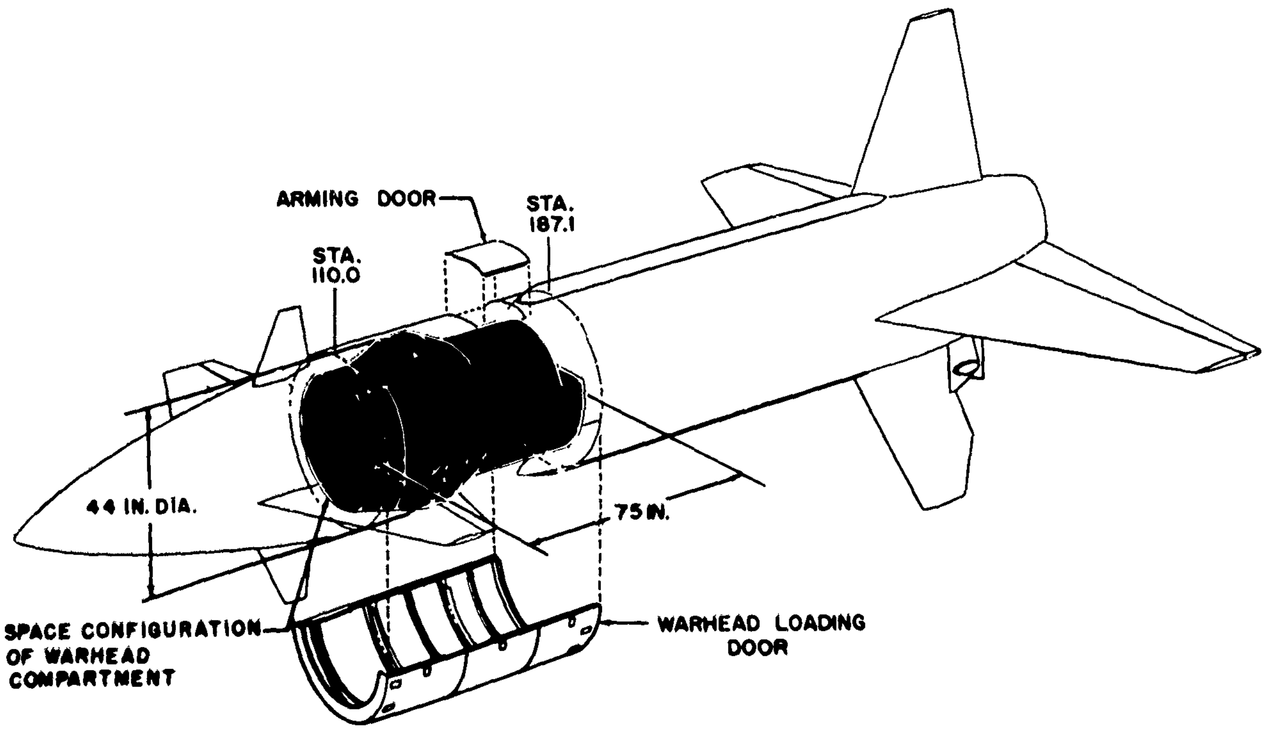


Figure 15. Configuration of GAM-63 Warhead Compartment

ability effective on No. 87 and subsequent missiles (see Section II, D, 1, GAM-63 Airframe).

C. FUZING

The fuzing system arms and detonates the warhead. Detonation is triggered by a firing baroswitch that can be preset for operation at the selected pressure altitude. Remote selection of a pressure altitude setting for the fire baroswitch may be made from the director aircraft during the prelaunch phase. Detonation can also be made to occur on impact.

A requirement was established for a fuzing system to be operational with the alternate warhead. At conferences with Sandia and Special Weapons Center personnel, the necessary technical and background information was made available. Preliminary mock-up and testing of the fuzing system was then initiated with available components. This preliminary review indicated that the proposed circuitry and component selection was acceptable. The new switch uses the existing type lanyard switch, an MC-384 arm-safe switch, an MC-394 fuzing baroswitch, and an MC-273 arm baroswitch. The control power supply is derived from MC-271 batteries. The arming control panel is a T-249 type. Impact crystals with higher levels of voltage output are also provided.

A separation timer was not proposed in the system because such a unit is incompatible with a free-fall type of operation. Monitoring indications of system adequacy are not available, but failure monitoring may be accomplished by a red light displayed on the T-249 panel. The red light indicates malfunctions of the arm/safe switch, high-voltage battery actuation, and high-voltage switch actuation.

Work is continuing on the evaluation of baroswitches from an alternate vendor. This vendor has produced switches that are adequate except for occasional freeze-up of the setting motors at low temperatures and high relative humidities. This trouble is similar to that encountered with the MC-5 fuzing baroswitch.

The MC-394 fuzing baroswitches ordered for evaluation have been received and testing is scheduled to begin in the next quarter. It will be necessary to design a vibration isolation mount which is compatible with both the fuzing baroswitch and the missile before the mount can be designated for use in an EAST missile.

Further determination of lags in the sensing system at various Mach numbers has been accomplished. Excessive lag was detected in the instrumentation position of the sensing system. This must be corrected before reliable data can be obtained relative to fuzing baroswitch closure altitude.

The fuzing data gathered from the flight of XGAM-63 No. 4075 represents the fifth set of applicable MC-5 pressure-sensing data obtained to date. Since Askania position data have not yet been received, an analysis of the fuzing system of this missile has not been performed. Additional data will be required on future flights to prove both the magnitude and trends of pressure-sensing error with Mach number and altitude.

6 Instrumentation system

A. SYNOPSIS

Four groups of telemetering systems are used in XGAM-63 missiles. Group I was used in Model 56N and 56D XGAM-63's and in eight of the Model 56F missiles. Group II systems were used in the early Model 56F missiles, and Group III systems are being used in all the remaining missiles. Group IV are installed in a limited number of R&D Model 56F missiles to supplement the Group II or Group III systems.

1. Group I System

The Group I system has been used to transmit both qualitative and quantitative data on vital components and systems. The number of continuous telemetering channels has been varied from six to eighteen. By commutating as many as four of these channels, data transmission of up to 94 functions has been obtained. Telemetering instrumentation for Group I on early XGAM-63's includes accelerometers, angle-of-attack and sideslip vanes, various pressure pickups, rate gyros, position potentiometers, and numerous a-c and d-c voltage-measuring units. In addition, special flights with Group I telemetering instrumentation included vibration pickups, flowmeters for measuring hydraulic flow, strain gages for measuring control surface hinge moments, and oscillographic recorders for obtaining structural data on control surfaces and airframe. Special provisions have also been made for

recording impact data obtained from fuzing accelerometers.

2. Group II System

Group II telemetering systems use four subcarrier channels, three continuous and a fourth commutated to provide 27 subchannels. Automatic decommutation is incorporated whenever ground-gating is available. In this system, accurate pressure-altitude data are transmitted on a continuous channel. In general, most end instruments supply only qualitative data.

3. Group III System

The Group III telemetering system is electrically similar to the Group II system in that four subcarriers similar to the Group II system in that four subcarrier channels are used, three of which are continuous and one commutated. Automatic decommutation is incorporated when ground-gating is available. This system, unlike the Group II system which is battery-operated, is powered by a 400-cycle rectifier-type power supply. A thyratron assembly is included to provide qualitative data from impact accelerometers.

4. Group IV System

Group IV telemetering systems are reworked Group I systems which provide a dual r-f system with 16 or 19 subcarrier oscillator (SCO) channels. This system has been added to provide additional environmental, power plant, and reliability data on some of the R&D Model 56F missiles. Provisions are made for telemetering two information commutators, two temperature commutators, and two vibration commutators. Wherever used, the Group IV system is in addition to a Group II or III systems.

B. OPERATIONAL RESULTS

Two XGAM-63's were fired during this quarter. Environmental data were telemetered on these flights during all phases including director take-off and climb, and missile launch. These data comprise vibration, acceleration, and temperature information on selected locations throughout the missiles. Detailed analyses of the two flights are discussed in Section II, B, Flight Testing.

C. TELEMETERING DESIGN AND DEVELOPMENT

1. Group I and II Telemetering Systems

All Group I and II telemetering systems have been expended in the flight test program at Holloman Air Development Center.

2. Group III Telemetering Systems

Instrumentation has been rearranged in missiles equipped with Group III systems to facilitate gathering power plant information. The units for this system are being fabricated with increased component lead lengths as initiated during the last quarter. Specifications for these systems were revised to incorporate outstanding amendments and deviations. These revisions should clarify all requirements.

Drawings for the entire Group III System were changed; it is now mandatory to use Bell Aircraft specifications for the procurement of all component parts. This is a major step in an attempt to build reliability into each unit by controlling parts received from outside sources.

3. Group IV Telemetering Systems

The major effort during this quarter has been directed toward the completion of drawings for the last units of the Group IV systems. These systems utilize Raymond Rosen subcarrier oscillators which have low-level distortion characteristics. All units with an assigned effectivity have been fabricated, tested, and installed in missiles 79 through 83. One spare set has also been fabricated and tested successfully.

Design and drawings are complete for the vibration equipment (with a response of 2000 cycles) scheduled for use in GAM's 98 and 102. Fabrication, testing, and installation is planned for the next quarter. Test instructions and detailed channel assignments have already been completed and are being released.

E. Support Aircraft

1. SYNOPSIS

The director aircraft that form an integral part of the Rascal Weapon System are converted B-47 strategic bombardment airplanes, redesignated as DB-47. Their primary mission is to carry the GAM-63 missile to an area within 90 nautical miles of a target, to launch the missile at a particular altitude and heading, and to provide guidance control of the missile after launch.

In the Rascal R&D flight test program, three types of carriers are being utilized. The JB-50D airplanes are used to ferry GAM-63 missiles and related equipment from the Wheatfield plant to various test installations. The JDB-36H and DB-47E director aircraft are used for flight testing GAM-63 missiles.

Also, one JB-17G, one JF-80B, and one JF-89C are assigned to the MX-776 program for R&D flight testing of components of the missile and director aircraft guidance systems.

In addition to modified MA-5 or -8 navigation gear, the director aircraft are equipped with an AN/APW-17 radar course-directing central. This equipment is used for navigating the director to a predetermined launch area, for preparing the missile prior to launch, for launching the missile, and for correcting the flight path of the missile during its midcourse phase and terminal dive to the target.

2. DIRECTOR AIRCRAFT

a. DB-47 Operational Directors

Detailed installation data for the DB-47 have been issued in Bell Aircraft Report 110-947-005, "Installation Requirements, DB-47 Director Aircraft." The GAM-63 when loaded on the DB-47 is attached to a pylon protruding from the fuselage and is mounted in an attitude so that the angle of yaw is zero, the angle of attack is as small as possible, and the angle of roll does not exceed 13° (see Figure 16).

Late in 1954, the DB-47E (USAF No. 51-5219) airplane and a simulated GAM-63 missile were trans-

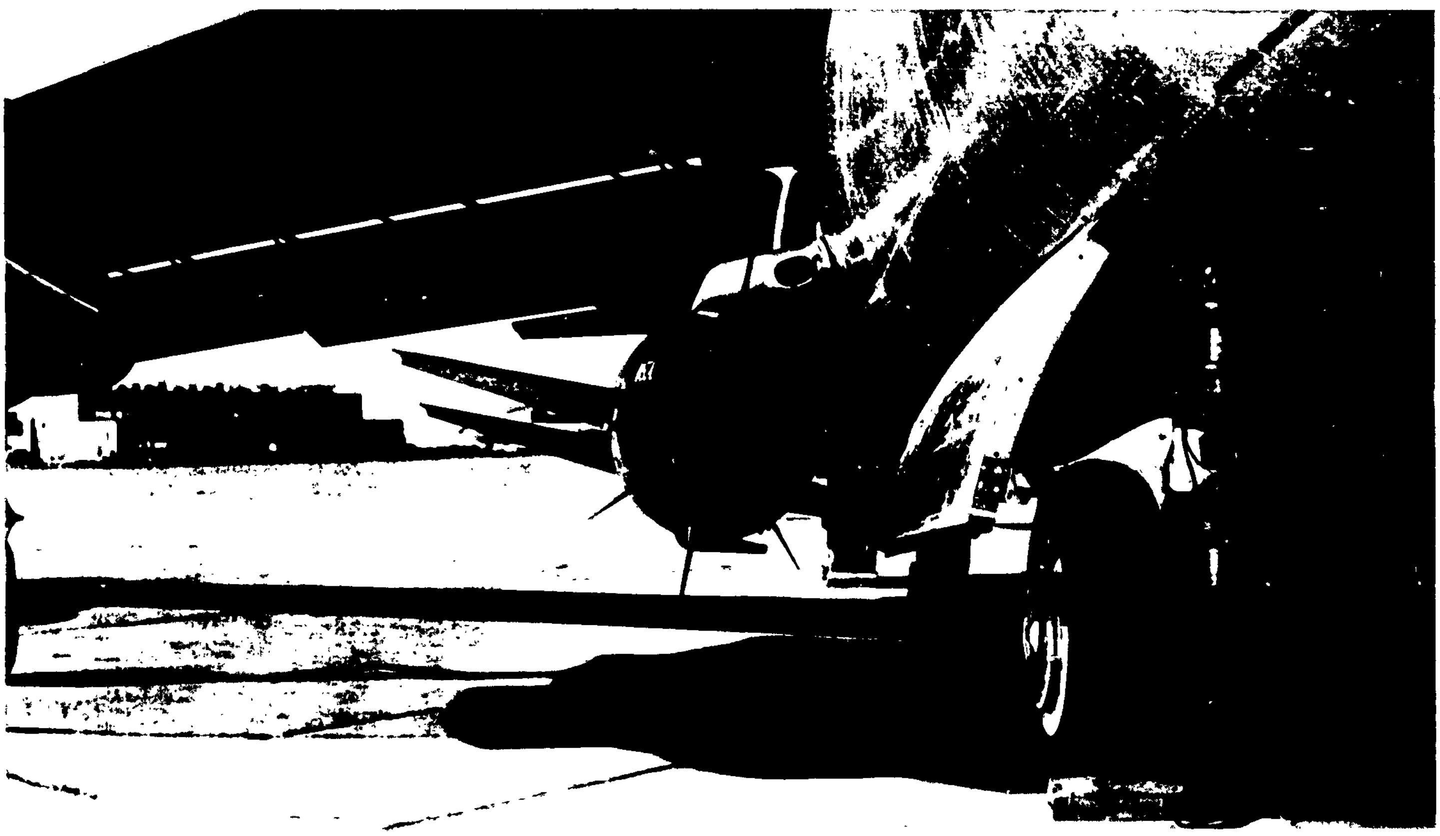


Figure 16. Rascal Missile Attached to DB-47 Director Aircraft

ferred to Edwards AFB for extensive flight testing by the USAF. The launching mechanism on this DB-47 was tested by dropping the simulated missile; motion picture coverage indicated satisfactory operation. Subsequently, AN/APW-17 guidance equipment and a flight test recording system were installed in the airplane. During this quarter, the DB-47 was used in the captive flight testing of missile No. 4277. Captive flights with GAM-63 No. 61 were also accomplished.

Another DB-47E (USAF No. 51-5220), complete with Rascal guidance components, was delivered to HADC in August 1954. Instrumentation was subsequently installed for recording missile and director aircraft guidance performance, and missile power plant and airframe operation. Following missile mating and captive flight testing, hot firings of GAM-63's with this airplane as director began in July 1955. The aircraft has been prepared for flight testing missiles of No. 4075 configuration. During this quarter, the DB-47 was utilized to launch missile No. 4277 and in the captive flight test program with GAM No. 61 (see Section II, B, Flight Testing). It is planned to use this DB-47 for the launching of missile No. 79.

b. DB-36 R&D Directors

The JDB-36H director airplane (USAF No. 51-5710), equipped with AN/APW-17 guidance, was transferred to HADC in July 1954. Following the installation of a flight test recording system, this DB-36 was used for captive flight tests and for launching GAM-63's. During this quarter, the DB-36 was used for captive flights with GAM No. 61 and the hot firing of missile No. 4176. The airplane is now being used for R&D test flights.

A second JDB-36H airplane (USAF No. 51-5706), equipped with AN/APW-17 guidance, was delivered to HADC in December 1954. Following the installation of a flight test recording system, the DB-36 was utilized for captive flight tests. Utilization of this airplane in conjunction with the Radar Bomb Scoring (RBS) program at HADC was completed successfully. The aircraft was subsequently transferred to Convair, Fort Worth, for a major overhaul. After its return to HADC, the DB-36 will participate in the Electronic Vulnerability Test (EVT) Program with the JF-80 simulated missile.

3. DIRECTOR AIRCRAFT EQUIPMENT

a. General

The DB-47 director aircraft used with the Rascal Weapon System are equipped with an AN/APW-17 radar course-directing central and an MA-8 bombing-navigational computer. Director guidance equipment may be divided into four major systems: (1) the MA-8 is a bombing navigation system designed for either gravity bombing or providing initial conditions to the GAM-63; (2) the automatic checkout system, working in conjunction with the MA-8 and auxiliary components, is used prior to missile launching to check selected critical items in sequence, and to launch the missile automatically; (3) the relay link system establishes and maintains a microwave radio link between the missile and director aircraft; and (4) the guidance control system which enables a trained operator to send azimuth corrections during the midcourse phase, and azimuth and pitch corrections during the terminal dive.

Specification 110-947-198, Revision B, defining the requirements for bench tests, installation tests, preflight tests, and flight tests of the AN/APW-17 and MA-8 systems, and reflecting the dual warhead configuration, is in work and will be submitted to the WSPO in November 1956.

Three of eight prototype AN/APW-17 director aircraft guidance systems have been modified to incorporate approximately 30 design changes considered necessary to obtain improved performance and reliability; these units were delivered to HADC for use in the flight test program. A fourth prototype system, similarly modified, has been delivered to Eglin AFB for use in the EAST program. Three other prototype systems have been modified and are in various stages of testing prior to delivery to HADC. System No. 7, the last of the eight prototypes, is undergoing modification.

The production AN/APW-17 system No. 107, incorporating approximately 70 engineering changes, has been acceptance-tested and delivered to Boeing/Wichita. All drawings and specifications have been changed to reflect system No. 107 and subsequent.

Engineering data have been released to incorporate dual warhead capability into both the production and prototype AN/APW-17 systems. This change will be incorporated into production system No. 117 and subsequent during manufacture, and into prototype systems Nos. 7 and 13 prior to their delivery to HADC. The remaining production and prototype systems will be modified by means of service kits.

b. Radio Repeater Set

(1) Automatic Tracking Relay Antenna System (ATRAS)

Extensive work has continued on product improvement and reliability modification and, in most

cases, these changes have been proven under severe environmental conditions.

Dalmotor Company is evaluating a new spin-drive motor intended to replace the present ATRAS spin-drive motor which has a high failure rate.

(2) Polycode Driver

Hermetically sealed pulse-forming networks have been evaluated and are scheduled for installation in both prototype and production units of the polycode driver. In addition to increasing pulse-width accuracy, these networks are expected to provide higher reliability over a wider range of environmental conditions.

(3) Command Transmitter

Continued testing of the new magnetic amplifier AFC circuit has demonstrated improved magnetron tuning capabilities. The first set of redesigned microwave plumbing was tested and results were close to predicted values.

Both mechanical and electrical design as well as layout of the new command transmitter are nearly complete. The package will be pressurized and will be approximately the same size as the existing transmitter.

(4) Relay Receiver

Breadboard development of a narrow-band relay receiver was completed early in this quarter, and construction was started on an R&D developmental prototype. This model, approximately 75% complete, will feature subunit construction for ease of repair, maintenance, and trouble-shooting. Each subunit is being tested upon completion of construction, and bench evaluation of the entire receiver will be conducted after all construction and assembly are accomplished. As presently planned, the new receiver will be sent to HADC for in-flight testing and evaluation during the R&D Captive Flight Test Program.

On the design prototype of the narrow-band receiver, the first models of the AFC amplifier, AGC amplifier, video IF strip and video amplifier, and power supply have been completed and testing has begun. The first models of the antenna IF error signal amplifier and the threshold relay assembly are nearly complete.

c. Terminal Guidance Control Station (TGCS)

(1) Azimuth, Range, and Altitude (3-D) Offset Computer

Bids for the subcontracting of work on the offset computer have been received from 10 vendors. The subcontract will be assigned after USAF approval and incorporation of this item into the work statement of Contract AF33(600)-31948.

(2) Indirect Bomb Damage Assessment (IBDA)

Preliminary environmental tests of the IBDA marker unit have been completed. The tests indicate that the Bell-designed oscillator will provide the specified performance over the required temperature range. Mechanical modifications have been completed and it is expected that vibration tests will begin during the next quarter. Service test models will be fabricated for flight evaluation at HADC.

The moment of inertia of the detector head has been determined and a mock-up of the mount is being fabricated. This mock-up will be used for preliminary electrical and mechanical tests under environmental conditions.

(3) Improved TGCS

A laboratory prototype of the improved synchronizer has been constructed and is being checked out. This model will be used for preliminary environmental tests and for flight tests at HADC. Flight tests will be conducted in conjunction with testing of the narrow-band system.

A laboratory model of the improved range computer has been constructed. The model will be checked on the bench, then used in air-to-laboratory tests at the Wheatfield Plant, and finally in flight tests at HADC.

d. Automatic Checkout System (ACS)

The continued program for improving electronic equipment is resulting in the redesign of the automatic checkout system. Redesign will take advantage of field tests experience, latest techniques, and more recent component developments. All parts not required for the present countdown prior to missile launch will be eliminated. Testing, maintenance, and fabrication will, therefore, be greatly facilitated. Removal of parts and circuit simplification will increase system reliability. Drawings for the more-reliable system will be completed by February 1957.

Automatic checkout system No. 109 was delivered to Boeing/Wichita after successfully passing all tests.

An ACS/GAM-63 group simulator (Bell Dwg. 112-542-500-1) is in use at Boeing. (The group simulator is a unit used to verify correct electrical installation of portions of the AN/APW-17 and MA-8 systems in the DB-47.) All operational difficulties, mainly those of procedure, have been eliminated and Specification 110-542-198 has been amended where applicable. Thus far, two simulators have been delivered to Boeing and a third is at HADC.

Design work for the extended capability simulator (Bell Dwg. 112-542-500-5) is in the final stages. This simulator will quantitatively check out the ACS as well as the MRNC equipment and is compatible with AN/APW-17 system No. 117 and subsequent.

A 1000-hour life test, with a flight simulated each four minutes, has been completed. The only malfunction occurring was corrected by lubrication of a two-phase motor. There were no failures of tubes, resistors, or similar parts. Figure 17 shows the bench setup for this automatic life testing program.

4. FERRING AIRCRAFT

Two JB-50D ferry airplanes (USAF Nos. 48-069 and 48-126), equipped with GAM support fittings and bomb-bay cargo platforms, are assigned to the Rascal program. These aircraft are operated from the main plant at Wheatfield, New York, to deliver GAM-63 missiles and related equipment to the various test installations (see Figure 18).

5. RESEARCH AIRCRAFT

a. General

The JB-17G airplane (USAF No. 44-8339) is based at Bell Aircraft's main plant in Wheatfield, New York. This airplane has been used in conjunction with the JF-80B airplane for research and development of components of the director and missile guidance systems.

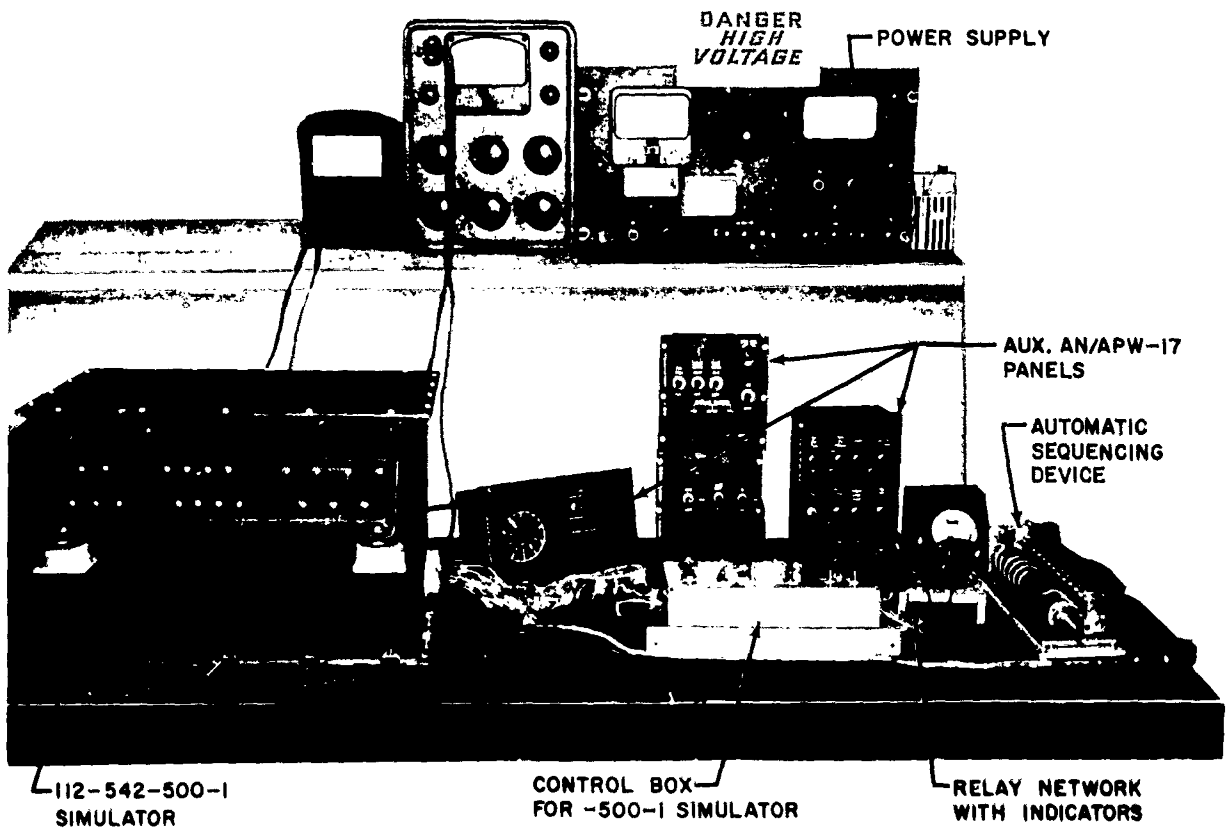


Figure 17. Setup for Life Testing GAM-63 Group Simulator

Figure 18. JB-50 Ferrying Airplane

The JB-80B airplane (USAF No. 44-8485), stationed at the Wheatfield plant, has been used as a simulated GAM-63 and in the R&D guidance program conducted with the JB-17G airplane.

The JF-89C airplane (USAF No. 51-5814) has been structurally modified and instrumented to simulate the GAM-63 missile. This airplane, in conjunction with DB-36 No. 51-5706 was used during the quarter at HADC for the first flight of the RBS Program. The F-89 (see Figure 19) and a ground crew was subsequently transferred to Luke AFB, Phoenix, Arizona, where the formal RBS Program is being conducted.

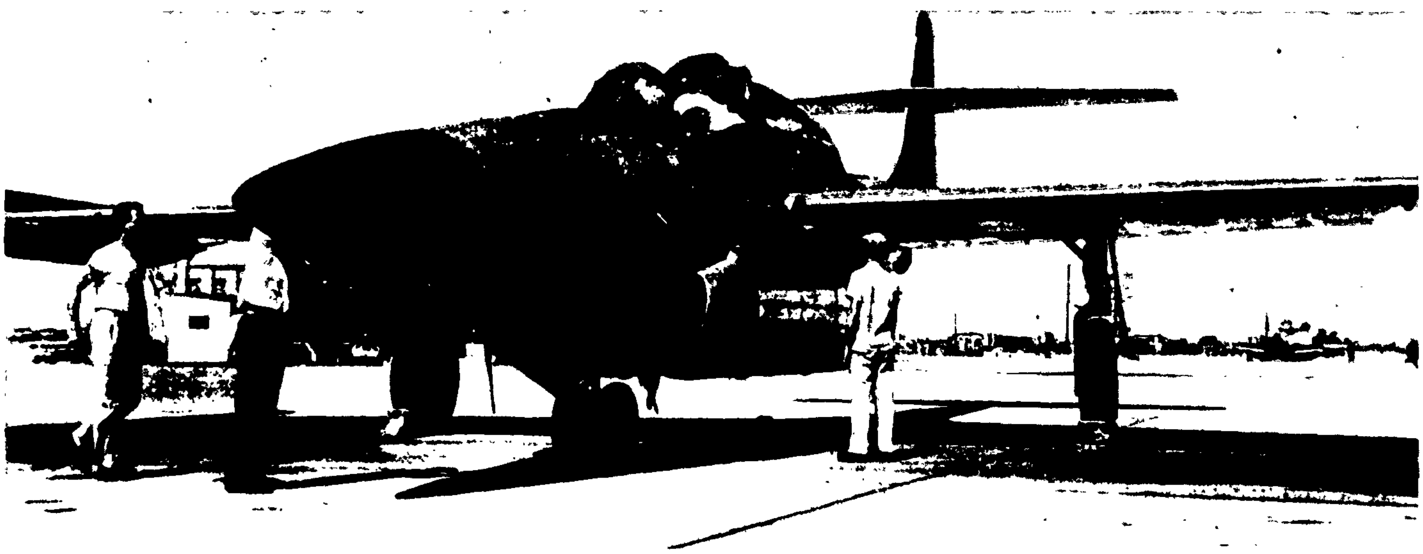


Figure 19. Preflight Preparation of JF-89 Research Airplane

b. Guidance Flight Testing

(1) JB-17G No. 44-83439

This aircraft has completed the fifteenth periodic inspection and is again ready for use in guidance test flights.

Flight tests were made during this quarter to collect data on the AGC circuit of the radar set for HADC. As a result of the three flights performed, an acceptable method was evolved to achieve proper AGC action with the single PRF system at all altitudes.

During other flights, conducted to evaluate the improved TGCS range unit, further improvements were made on the altitude tracking circuit. The development of this circuit is essentially complete and only details remain to be corrected.

One flight was performed to evaluate the TGCS (part of the AN/APW-17) with 1N300 diodes installed in the altitude tracking circuit. These diodes were installed to permit operation of the equipment when exposed to high ambient temperatures. The results of this flight indicated that these components permit the circuit to function normally.

Several ground tests were made to evaluate a signal divider which was built to allow two indicators to be operated simultaneously with the TGCS. Results of these tests indicate that the signal divider functions satisfactorily.

(2) JF-80B No. 45-8485

During this quarter, the missile guidance equipment installed in the F-80 was modified to include the latest antijamming features. Ten flights were performed to evaluate this modification and to verify that the aircraft is in proper condition for use in the EVT Program at HADC. The pilot and several technical persons returned to the Wheatfield plant to become familiar with the operation of the new equipment. The aircraft and associated equipment were subsequently transferred to HADC on 20 August 1956. An effort is now being made to ship the final group of spare guidance units.

(3) JB-50D No. 48-111

The B-50 arrived at the Wheatfield plant on 27 June 1956. Although this airplane will replace the more obsolete B-17, authority has not yet been granted to initiate the change-over. Some effort has been spent in planning the installation of equipment for the B-50.

The B-17 command package has been modified to permit the use of a third command channel to control the threshold voltage of the radar set. Flight tests are planned to evaluate this modification.

F. Ground Support Equipment

1. SYNOPSIS

The ground support equipment for the GAM-63 Weapon System encompasses all equipment not an integral part of the missile or director aircraft, but which is required to service, repair, test, and prepare the weapon for launching. Support equipment, therefore, includes handling and transporting devices, assembly stands and slings, special loading and fueling units, checkout/test equipment, and special templates and tools.

Over-all planning relative to support equipment for the Rascal Weapon System is divided into two major categories. The first includes plans for equipment needed to conduct the contractor's ground and flight test programs, and the other includes planning pertinent to the Rascal support equipment required by the Air Force under operational conditions.

2. SUPPORT EQUIPMENT FOR THE R & D PROGRAM

All items of support equipment for conducting the Rascal R & D flight test program are available for current requirements. Changes made to other elements of the weapon system occasionally bring about modifications to existing ground support equipment; these modifications are accomplished as the need arises. Progress on new-design development work is presented in Figure 20. This work is in support of new design work for other elements of the weapon system as listed in the illustration.

a. Handling Equipment

Engineering design work was completed on protective covers for the GAM-63 horizontal wing surfaces and the aft vertical fin in the folded position.

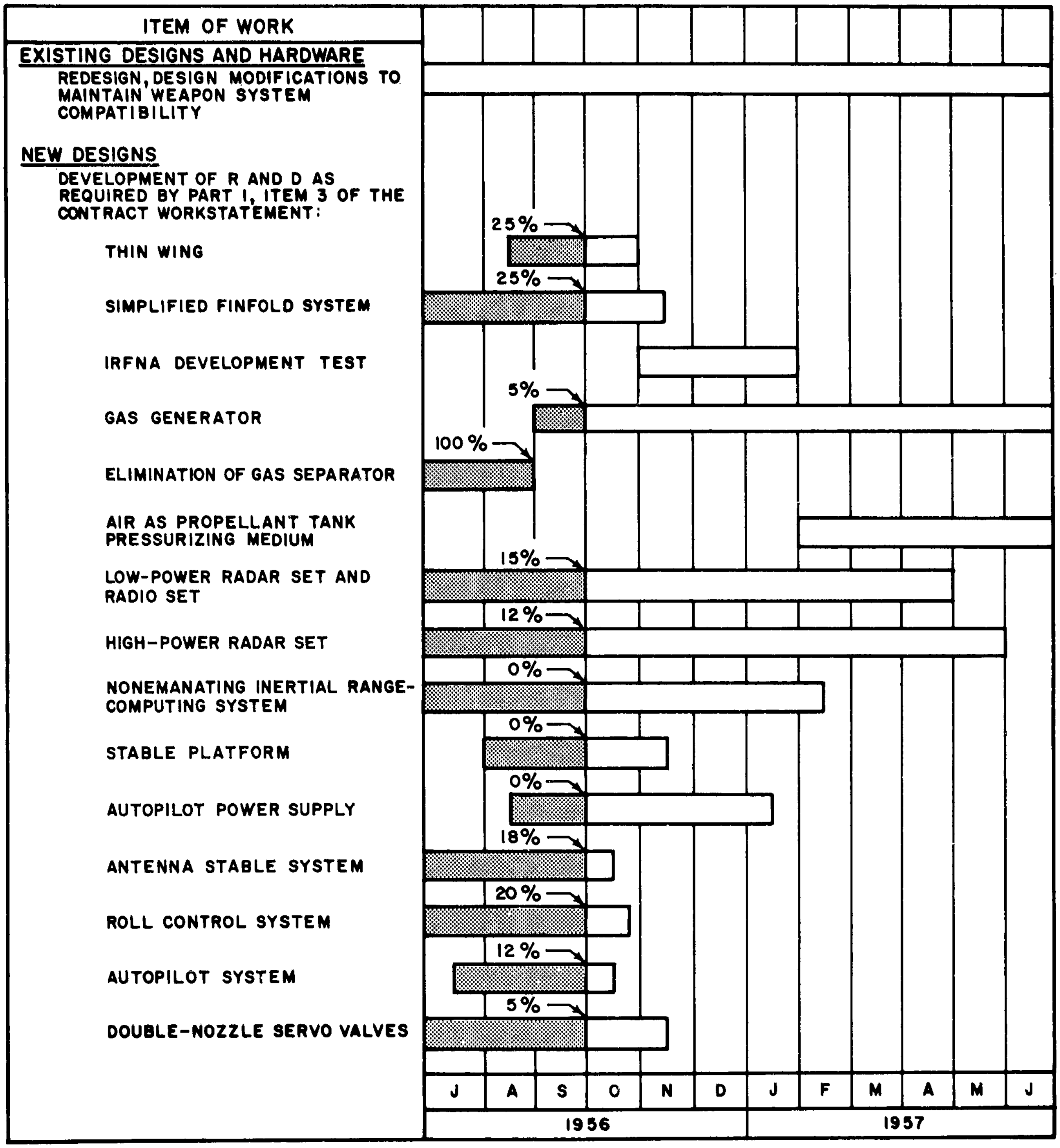


Figure 20. Ground Support Equipment Improvements

The protective covers are of an improved design for ease of handling and application.

b. Service Equipment

The test article of the Flush and Disposal Trailer (see Figure 29, Report 56-981-021-45) was completed during this quarter and is presently undergoing evaluation at AF Plant No. 38.

c. Director Aircraft Checkout Equipment

Modifications necessitated by changes in the AN/APW-17 guidance system were made during this quarter.

d. Missile Checkout and Test Equipment

To accomplish systems testing of GAM-63's, 16 test stations have been fabricated and installed at the Wheatfield Plant, Air Force Plant No. 38, and Holloman Air Development Center. Efforts are continuing to incorporate into this test equipment, weapon system changes and improvements determined from operating experience. In addition, Station M and the R & D Mobile Unit are being maintained to perform tests for evaluation of engineering changes and/or development problems which affect systems testing. A listing of these test stations with their location and test capabilities is presented in Table V.

The R & D Mobile Checkout Unit was utilized in the hot-firing tests of GAM-63 No. 4277. After completion of the tests, the unit was returned to the Wheatfield plant for modification and maintenance. The unit will ultimately be relocated at AF Plant No. 38 for use in the Life Test Program to be conducted on GAM No. 78.

TABLE V

MISSILE TEST STATIONS

STATION	LOCATION	TEST CAPABILITIES
A-1	Wheatfield	Composite Systems
A-2	Wheatfield	Composite Systems
B-1	Wheatfield	Emanating and Nonemanating Guidance Systems
B-2	Wheatfield	Emanating and Nonemanating Guidance Systems
C-1	Wheatfield	Nonemanating Guidance and Standard Telemetering Systems
C-2	Wheatfield	Nonemanating Guidance and Standard Telemetering Systems
D-1	Wheatfield	Nonemanating Guidance System
D-2	Wheatfield	Nonemanating Guidance System
E-8E	AF Plant No. 38	Composite Systems
E-8W	AF Plant No. 38	Composite Systems
E-9E	AF Plant No. 38	Composite Systems
E-9W	AF Plant No. 38	Composite Systems
F	HADC	Composite Systems
G	HADC	Composite Systems
X	HADC	Composite (Portable)
Y	HADC	Emanating and Nonemanating Guidance Systems
M	Wheatfield	Composite Systems
R&D (Mobile Unit)	AF Plant No. 38	Composite Systems

The fuzing test equipment at Station A has been modified from a stationary to a portable unit and made compatible with GAM No. 73 (Station A-1) and GAM No. 87 (Station A-2).

Station M was supplemented with vibration equipment to accomplish Phase A-1 of the GAM No. 78 Life Test Program which was completed during this quarter. Station M is presently being used in support of testing and alignment of GAM No. 80.

The R & D Checkout Trailer (Bell Part No. 112-542-450-7) has been modified to make it compatible with GAM No. 87 in preparation for use in the ground support equipment evaluation program.

3. OPERATIONAL GROUND SUPPORT EQUIPMENT

The test article of the Flush and Disposal Trailer, completed during this quarter, is undergoing evaluation testing at AF Plant No. 38.

The Warhead Loader (see Figure 30, Report 56-981-021-45) and its operation and service handbook were evaluated with satisfactory results. A few minor changes were incorporated into the unit and its handbook as a result of the evaluation and the first two Warhead Loaders are ready for delivery to the USAF.

Emanating guidance, nonemanating guidance, fuzing, and calibration bench set equipment, being prepared for the Ground Support Equipment Evaluation Program, are 95% complete. Evaluation of the handbook, edited for the purpose of operation, service, and maintenance of the bench set equipment, is progressing concurrently with fabrication and is approximately 20% complete.

Engineering design work for adding an outrigger to the base of the aft body stand of the missile has been completed. The outrigger will prevent an unloaded stand from overturning when its boom hoist is used for removal or installation of a missile rocket engine.

The first production unit of the Rocket Engine Analyzer (Bell Dwg. No. 112-789-482-1) was completed during this quarter and inspection tests are being conducted prior to evaluation.

A drawing review program was conducted on all drawings pertinent to ground support equipment, prior to contractual delivery of the units. The review was conducted to ensure that the drawings are compatible with current operational design configurations.

A Development Engineering Inspection (DEI) on operational ground support equipment, conducted at Bell Aircraft's Wheatfield facility on 15 through 17 May 1956, resulted in 86 discrepancies, all of a minor nature. The following Form 68's were submitted:

Category		Quantity
I	Inspection Items (to be accomplished so that equipment will meet USAF requirements)	35
II	Mandatory Changes (Engineering Change Proposals)	13
III	Study Changes (of a nature which will require a study)	23
IV	Not applicable or acceptable	17
	Total	86

Of the 35 inspection items listed in Category I, 33 have been accomplished and are being reviewed. All engineering design changes have been completed on the items in Category II. Studies have been completed for 21 of the 23 changes listed in Category III.

Figure 21 reflects the progress on new design efforts for squadron ground support equipment. Fabrication of this equipment, which is progressing concurrently, is approximately 20% complete.

As a part of the work effort on Project MX-776, a program is under way at HADC to evaluate operational ground support equipment. The evaluation consists of actual usage of each item, in accordance with its applicable handbooks, during the preparation of GAM-63 missiles for launching. In addition, the handbooks associated with each item are evaluated for suitability and accuracy in describing operation, maintenance, and repair.

During this quarter, four items of support equipment were partly evaluated. Two items, the rocket engine stand (Bell Dwg. No. 112-782-588) and the fuel-line fill unit (Bell Dwg. No. 112-789-481) have been completely evaluated. The rocket engine stand (see Figure 22) and its associated handbook were found to be compatible and suitable for operational usage. The fuel-line fill unit requires slight modification and its handbooks require minor revisions to ensure compatibility.

Four additional items of ground support equipment are being evaluated: the search antenna guard, the warhead compartment strut, the warhead door dust shield, and the hydraulic test stand. Evaluation of the first three of these items will be completed during the preflight preparations of missile No. 79.

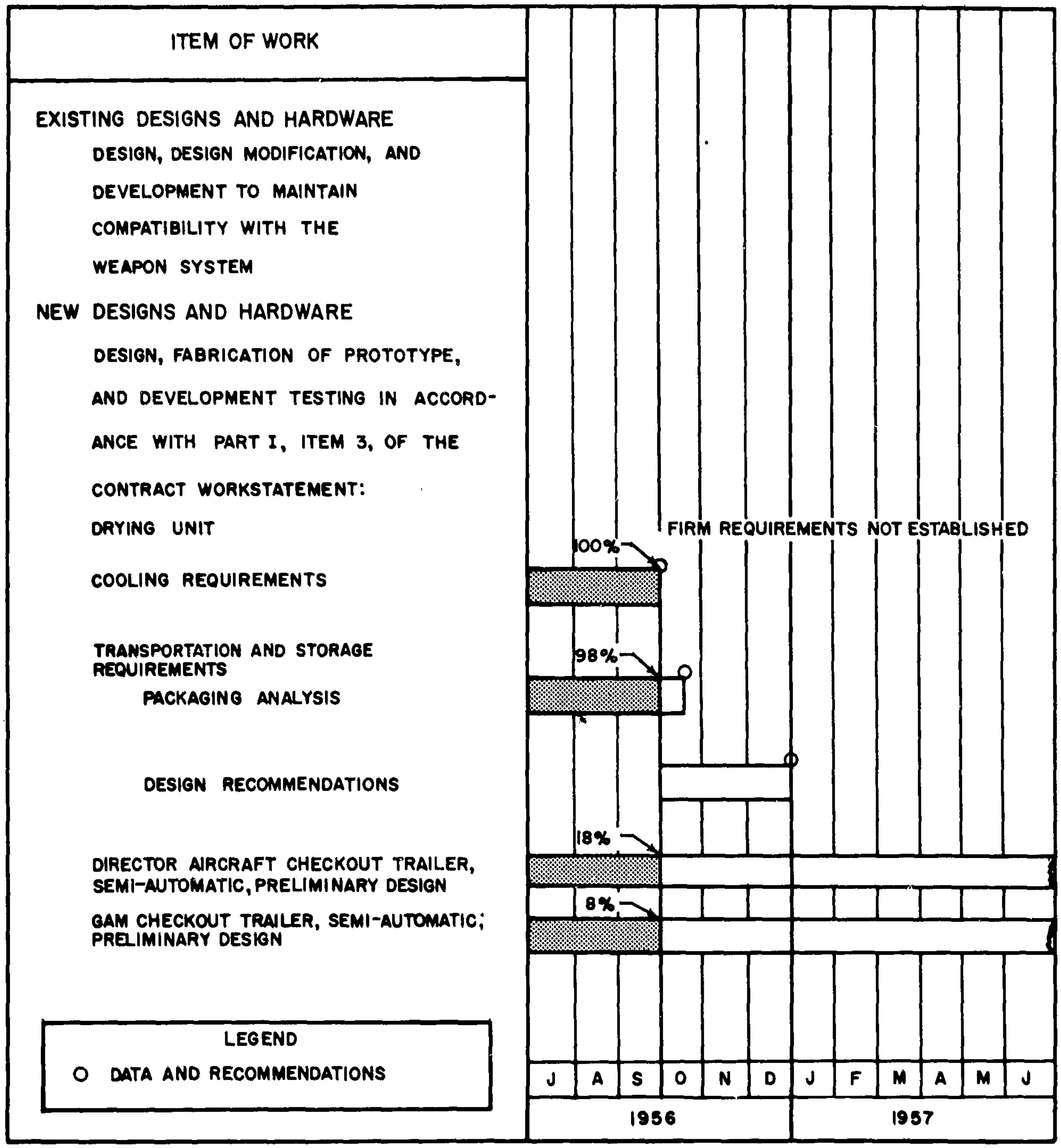


Figure 21. Squadron Ground Support Equipment Programs

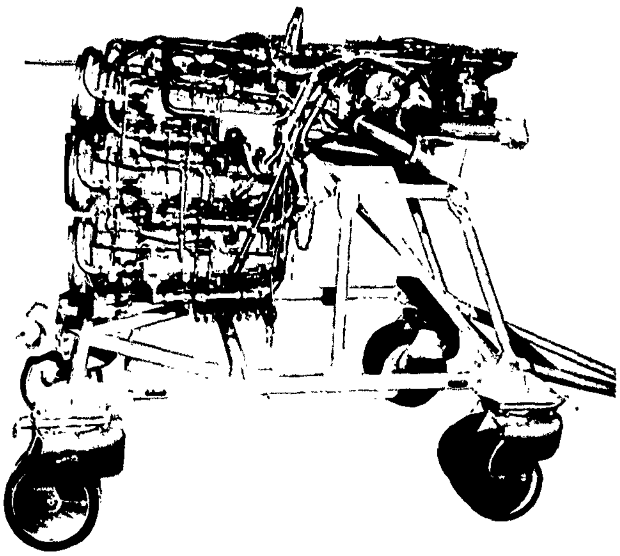


Figure 22. GAM-63 Rocket Engine and Rocket Engine Stand

G. Training Equipment

1. SYNOPSIS

Training equipment for the GAM-63 Weapon System falls into two categories: the equipment for training maintenance personnel and the equipment for training operations personnel. Figure 23 presents the status of the training equipment programs.

Classroom demonstrators for the GAM-63 systems and the AN/APW-17 radar course-directing central in the director aircraft have been designed, fabricated, and delivered to the Air Force. Also, a team of F-80 and B-50 aircraft, modified and instrumented to simulate the GAM-63 and the DB-47, has been delivered to the Air Force.

2. MAINTENANCE TRAINING AIDS

The Mobile Training Unit (MTU) is being designed in accordance with Air Force Exhibit WCE-280 including Amendment IV.

The missile portion of the MTU consists of 14 units. Seven of the units portray systems in the missile, while five others contain checkout and test equipment for those systems. The remaining two units supply power for operating the complete set. All missile units of the MTU, except the Rocket Engine Analyzer Trainer, have been designed and released for manufacture. Design of the Rocket Engine Analyzer Trainer is nearly complete.

The director aircraft portion of the MTU consists of 11 units. Six of these portray Rascal systems located in the DB-47, three are test equipment, and two are units that supply power for operating the complete set. The Bombing-Navigation Computer (Modified ME-6) Trainer is being designed. All other units have been released for manufacture.

3. OPERATOR TRAINING AIDS

The Rascal Guidance Operator Trainer (RGOT) has undergone continued improvements, based upon operating experience. These are in addition to the normal changes authorized for the weapon system. At present, the entire trainer is being brought up to date. A new optical system for the radar simulator is being constructed and should be completed, although not necessarily installed in the trainer, during the next quarter. It is anticipated that this new optical system not only will simplify the adjustments for aligning the simulator, but also will increase the light transmission efficiency of the system.

An all-optical target-briefing device is being designed and fabricated. The design work is progressing with two main objectives in view. The first consideration is to produce, on the simulated radar screen, a picture that is as realistic as possible with an all-optical system. This is important from the standpoint of training the guidance operator to recognize the target on an actual radar screen after the operator

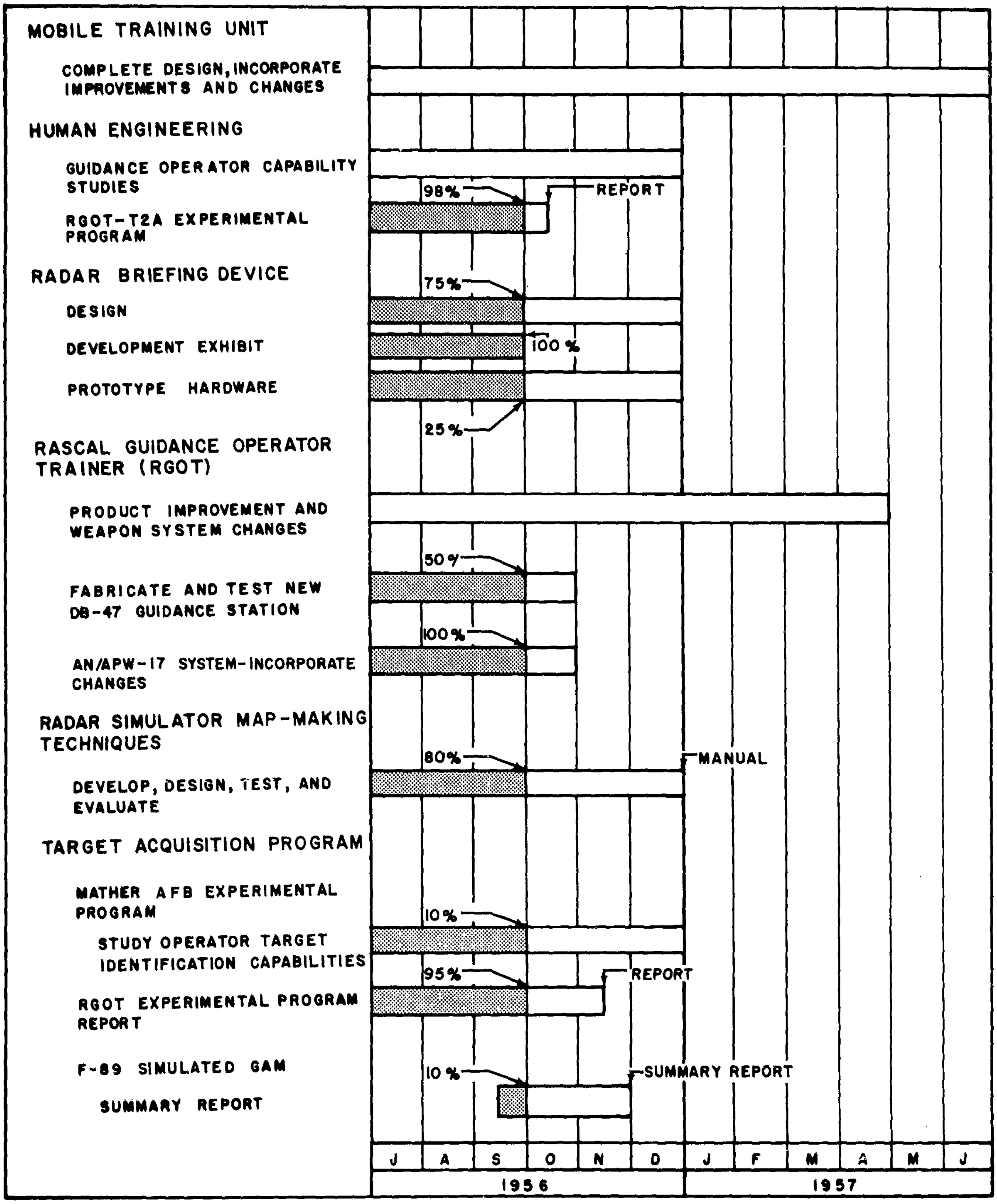


Figure 23. Status of Training Equipment Programs

has been trained on the target-briefing device. The second design consideration is portability. To be of maximum value for briefing purposes, the unit must be capable of being readily moved without the aid of handling equipment. Based on this criterion, design of the unit is such that one, or possibly two, men can unload the device from a truck, carry it to the assembly site, and assemble the unit without the need for handling equipment.

4. TARGET ACQUISITION AND RGOT MAP EVALUATION PROGRAM

Contract Change Notification No. 27, received in November 1955, defines and authorizes the Target Acquisition and RGOT Map Evaluation Program. Progress on the various phases of this program are presented in the following paragraphs.

The target acquisition investigation being conducted by AORL, Mather Air Force Base, is based upon scoring experienced Air Observer Bombardiers (AOB's) on the Bomb Run Simulator which contains properly modified Rascal scope photographs of Kansas City, Missouri. Prior to employing the Bomb Run Simulator, the operators are briefed both on scope photographs obtained with the RGOT and on enlarged artwork predictions furnished by Bell Aircraft. This program was started at the end of this quarter and the results will be presented in the next quarterly report.

The Target Acquisition investigation conducted at Bell Aircraft using the RGOT and SAC AOB's was completed during the first quarter of 1956. Although the report summarizing this investigation was delayed, pending reduction of accumulated data, it is currently undergoing final review prior to submittal to the Air Force in the next quarter. In the interim, the Guidance Operator Capability Program Report was prepared and is being readied for publication.

The third phase of the Target Acquisition Program was completed at Phoenix, Arizona, on 31 August 1956. This program utilized a JF-89 airplane (simulated GAM-63) under the control of SAC AOB's situated in a DB-36 director aircraft and operating under realistic strategic conditions. Eighteen dives were accomplished in the program; complete data were obtained on approximately 40% of the dives and partial data on the remaining dives. Data reduction and analysis are under way at Bell Aircraft's Wheatfield facility. In general, it is considered that the objectives of obtaining target acquisition information, as well as data for evaluating the guidance system and the open-loop control system, have been accomplished. A report on this phase of the program will be published during the next quarter.

An evaluation of the RGOT map-making techniques has been conducted by the Radar Bombing Branch, Directorate of Operations, Offfutt Air Force Base. This organization employed actual scope photographs obtained with the JF-89 over Kansas City and RGOT scope photographs obtained with a prediction plate of the same area. It is anticipated that the Radar Bombing Branch will submit a report on their findings during the next quarter.

5. HUMAN ENGINEERING

Results of the efforts in human engineering have been incorporated into the Target Acquisition and the Guidance Operator Capability reports mentioned previously.

H. Weapon System Investigations

1. GRAVITY BOMBING CAPABILITY

Studies relative to the gravity bombing capability have resulted in the plan to release three full-scale (modified Model 56B) GAM-63 airframes from a DB-47 under typical launch conditions. The airframe modifications have been completed and final system installation is under way. The rocket engines and other unnecessary equipment have been replaced with ballast; the airframe gross weight is identical with that of a fully loaded Model 56F missile. A program has been prepared for evaluating the pyrotechnic gas generating device which positions the ailerons after launch. The type and quality of telemetering required for the initial phases of the program have been determined. A simple battery-operated 5-channel FM/FM system will be utilized for the gravity bomb flight. In addition, two RF channels have been incorporated for initial evaluation work on the MC-616 impact crystal networks. Design work has been completed for installation of telemetering components; near-centerline mounting has been achieved to reduce centrifugal acceleration to a minimum.

Suitable end instruments will be provided in these test vehicles to measure pitch and roll rates and to monitor fuzing operation and aileron deflection.

Estimated completion for the first gravity bombing airframe is December 1956. Test range instrumentation at HADC will include full Askania cinetheodolite coverage from launch to impact, and motion picture coverage (chase plane) from launch to 10,000 feet altitude for obtaining trajectory characteristics and roll data.

In addition to the three airframes mentioned previously, additional vehicles and drop tests are contemplated to establish bombing tables and to determine CEP.

2. ALTERNATE TARGET AND AIMPOINT CAPABILITIES

In an effort to increase the flexibility of the weapon system, alternate target and aimpoint capabilities in the director aircraft post-take-off phase have been a subject of recent studies. The various approaches to the solution of the problem were summarized in a preliminary report submitted to the WSPO in June 1956. A progress summary report, presenting the results of analyses and laboratory tests of the selected solution for proving the feasibility of the design, was planned for submittal to the WSPO in November 1956. However, the modified commercial timers required for these tests have not been received from the vendor as scheduled. The publication date will therefore be delayed. A new submittal date will be established for the report after the timers are received.

3. CAPABILITY STUDIES

Bell Aircraft will prepare a document reflecting the results of studies that have led to the selection of the existing Rascal weapon. Although not all-inclusive, the document will reflect significant technical factors considered in establishing the basic weapon system configuration. The status of some of these studies are summarized in the following paragraphs.

a. Relay Link Requirements

A study of the requirements imposed on the relay antenna and autopilot stabilization systems by the Rascal relay link has been completed and a report of the results is being prepared. This study was based upon a theoretical development relating the error levels, which exist in certain GAM-63 and DB-47 systems, to the probability of maintaining the relay link during flight. The report will provide a means for determining the probability of success of the relay link (excluding catastrophic failures), given the error levels or specific accuracy limits in the various GAM and DB-47 systems, or for specifying the allowable error levels in these systems for a given probability of success of the relay link. The systems, or parameters, covered in this report are: (1) postlaunch flight path of the DB-47; (2) yaw (directional) gyro drift rate, (3) yaw autopilot error; (4) wind prediction errors; (5) launch heading error; (6) vertical (pitch and roll) gyro drift rate; (7) error of relay antenna positioning system; (8) roll autopilot error; (9) power output of missile relay transmitter, and (10) sensitivity of DB-47 relay receiver. The report also provides a means for examining the effect of radar set performance (target recognition), as well as that of relay signal attenuation due to adverse weather, on the success probability of the relay link.

b. Nonemanating Guidance System

Work is continuing on the error analysis of the Inertial Range-Computing System, based upon additional data on winds and magnetic heading accuracy.

c. Acceleration Limiting

Work on the command-limiting accuracy requirements as a function of missile maneuvering is continuing.

d. Offset Guidance Computer

The error analysis of the 3-D offset guidance computer is continuing (see Section E, 3, Director Aircraft Equipment).

4. STUDY OF MAGNETIC DATA ACCURACY

The problem of predicting variations in the earth's magnetic field for launch altitudes and launch areas associated with the weapon system is being re-examined to establish the magnitude of error contributed by this source to total heading error. Basically, error in predicting magnetic variation results from (1) lack of observed magnetic data and the necessity for predicting from out-dated information, (2) error in prediction technique used to extrapolate surface data to altitude data, and (3) inaccuracies in magnetic variation charts. Discussions with personnel at the Aeronautical Chart and Information Center and at several other agencies engaged in studies related to the evaluation of magnetic data have resulted in vital information on chart prediction errors. An extensive IBM calculation program is anticipated and an evaluation of this proposed program is under way.

5. LOW-ALTITUDE LAUNCH CAPABILITY

An investigation was conducted to determine the feasibility of launching Rascal at an altitude of 10,000

feet. A flight plan was prepared and preliminary results of this study indicate that the present weapon system configuration offers no fundamental obstacles to launching at this altitude. Present plans are to consult with the WSPO prior to investigating the feasibility of launching the GAM-63 at 5000 feet.

6. ANALYSIS OF PACKAGING REQUIREMENTS

The final packaging analysis report, No. 66-989-028, is nearly complete. Publication and release of this report is scheduled for the next quarter.

7. ELECTRONIC VULNERABILITY TESTS

The Electronics Vulnerability Test (EVT) Program utilizing the EF-80C (USAF No. 45-8485) and the JDB-36H (USAF No. 51-5706) aircraft was initiated in September 1956 at HADC. This effort is being conducted by the USAF with Bell Aircraft support to determine the susceptibility of the Rascal Weapon System to interception and analysis, and the degree of interference of missile performance that can be introduced by jamming and deception.

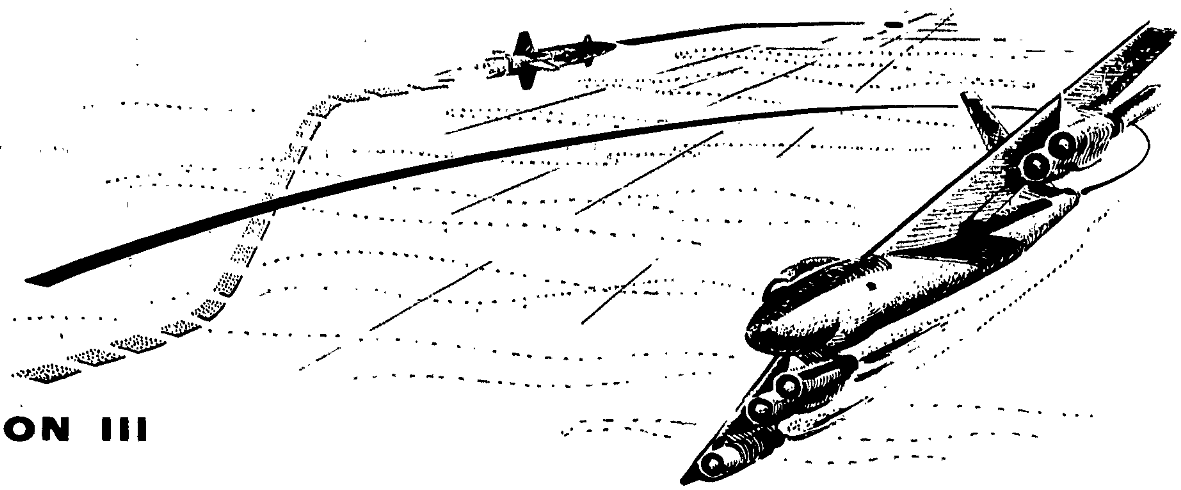
Implementing this program was a series of three DB-36 flights during which command transmitter and AN/APS-23 radar signals were successfully detected and analyzed. The resulting data should prove useful in planning future flight test operations. The DB-36 was subsequently ferried to Fort Worth, Texas, for a periodic inspection; this airplane is scheduled to be returned to HADC on 15 October.

Four missions were conducted with the JF-80 (simulated GAM-63) to intercept and analyze signals emanating from the radar set. During two of the flights, the magnetron frequency was not changed; on the other two flights, the antijamming feature was active. Useful data were obtained from all four missions.

Studies of AGC and AFC action of the relay receiver, under the influence of a jamming signal, are being conducted during a series of ground tests on electronic systems. The ten days of systems testing to satisfy the request of the Missile Countermeasures Laboratory is approximately 80% complete.

8. MISSION PLANNING DATA REPORT

A preliminary report, No. 66-989-021, dealing with mission planning, is being published and should be available in the next quarter. This document will present the basic data needed to prepare the Rascal Weapon System for a mission. The subject matter is separated into two categories. The first deals with flight planning information for operational employment of the weapon against strategic targets. The second category is concerned with flight planning instructions tailored for use at HADC during the EAST program.



SECTION III

AIR FORCE PROGRAMS

A. Employment and Suitability Testing

The operational suitability testing of Air Force guided missiles is under the provisions of AFR 80-14 which designates this function as the prime responsibility of the Air Proving Ground Command (APGC).

The Air Force On-the-Job-Training (OJT) program at Eglin Air Force Base will continue until the beginning of Employment and Suitability Testing (EAST). Sufficient GAM-63 weapon system hardware is available at Eglin AFB and the OJT program is under way. This hardware will be utilized in the ground phase of the EAST program which is scheduled to begin early in November 1956. Upon completion of the ground phase OJT/EAST effort, a preflight program will be undertaken and this will lead to actual missile launchings by the APGC test team during 1957. Planning for the OJT and EAST programs is presented in the MX-776 Program Planning Report, No. 56-989-003, Revision 18.

B. Logistics Depot

Bell Aircraft Corporation submitted a facilities proposal to AMC on 8 August 1955 covering the requirements for establishing a GAM-63 Logistics Depot at Air Force Plant No. 40 in the township of Tonawanda, New York. On 29 September 1955, AMC approved this proposal as Appendix A to Facilities Contract AF33(600)-31197.

On 5 October 1955, Bell Aircraft was awarded Contract AF36(600)-2667 for the overhaul, repair, and modification of GAM-63 components and related equipment, and Contract AF36(600)-2666 for the storage and distribution services of spare parts for the GAM-63 Weapon System. During this quarter, these contracts were extended by Supplemental Agreements to 30 June 1957.

The GAM-63 Logistics Depot will increase its working force to coincide with the increase of workload, either in the field or at the repair facility, as additional repairables generate during the progression of Air Force operations. Until the Depot is activated and the necessary equipment is obtained, all work which cannot be performed at the Depot will be accomplished at the Niagara Frontier facilities of Bell Aircraft Corporation.

The Logistics Depot will accomplish the work required for area support such as the DB-47 aircraft retrofitting at Eglin Air Force Base and at Holloman Air Development Center. Kits for the material for area support will be furnished by the Air Force. These kits will normally be manufactured by Bell Aircraft under Contract AF36(600)-2001.

C. Technical Training and Support

1. AIR FORCE TRAINING

As a result of three Air Force training conferences at Bell Aircraft Corporation (one from 10 through 19 March 1953, one from 31 March to 9 April 1953, and the other on 9 and 10 February 1954), a training program for Project MX-776 was formulated. These conferences were attended by representatives of AMC, WADC, ARDC, SAC, TTAF, and USAF Commands.

For these conferences, an outline for a training course was established, length and number of classes were agreed upon, and the categories of training, classification of trainees, and number of Air Force Commands that will participate were determined. Training of Air Force personnel (staff, AFOST, and instructors) is to be accomplished in three parts:

PART I - AF Staff Familiarization

PART II - AF Technical Training

PART III - On-the-Job-Training

PART I - The AF staff familiarization program extended from 12 July to 22 October 1954. A total of 175 USAF staff personnel attended a 40-hour academic program at Bell Aircraft Corporation.

PART II - A technical training program for approximately 95 USAF personnel began on 13 April 1955 at Lowry AFB, Colorado, and on 11 May 1955 at Chanute AFB, Illinois. This first class of trainees completed training on 28 June 1955. All training was completed on 8 November 1955.

PART III - A letter from WADC, dated 18 November 1953, requested that Bell Aircraft review the on-the-job training proposal outlined in HADC letter to ARDC, dated 19 August 1953. The WSPO and Bell Aircraft subsequently agreed upon the necessity for an OJT program at Eglin AFB.

To supplement the training programs already accomplished, additional approved and proposed USAF training programs are planned. Figure 25 of MX-776 Program Planning Report reflects the planning for these projects.

2. TECHNICAL REPRESENTATIVE SUPPORT

In support of the Air Force OJT/EAST program, Bell Aircraft Corporation has assigned technical and service representatives to Eglin AFB, Valparaiso, Florida.

A proposal has been submitted to SAC Headquarters covering contractor technical support for squadron activation and RGOT operation.

D. Handbooks

1. SYNOPSIS

In preparation for the EAST phase of the Rascal program, a complete set of maintenance and overhaul handbooks is being prepared to match the end-items of the weapon system: the missile, the AN/APW-17 director aircraft guidance system, and the ground support equipment.

Data in the handbooks include preparation for use, warm-up procedures, description of controls, operating procedures, theory of operation, trouble-shooting to isolate a malfunction within a system, removal and installation of components, trouble analysis to isolate a malfunction within a component, replacement procedures, complete teardown, inspection, lubrication, cleaning, reassembly, test, retest, and inspection. Test equipment will be given the same coverage as the equipment being tested.

Maintenance handbooks include information necessary for the operation and servicing of equipment at organizational (squadron) and field levels. Overhaul handbooks, to be used at depot level, will include information necessary for the repair of equipment which requires a major overhaul or complete rebuild of parts, subassemblies, assemblies, or end items.

To ensure a higher level of reliability for the GAM-63 Weapon System, an increase in the number of overhaul handbooks is anticipated and this area is now under study. The completion date for overhaul handbooks will be determined by AMC with respect to the operational date of the contractor-operated Logistic Depot of Air Force Plant No. 40.

2. GAM-63 MISSILE

All negatives for systems maintenance handbooks on the missile, except the Inspection Requirements Handbook and the List of Applicable Publications, have been delivered to the USAF. The remaining two T O's will be delivered when requested by the Air Force. Illustrated Parts Breakdowns (IPB's) for the missile are on schedule. All but one IPB (scheduled for delivery on 1 January 1957) will be delivered prior to the delivery of the first EAST missile; this does not include vendor-prepared IPB's.

3. GROUND SUPPORT EQUIPMENT

Negatives of required handbooks for ground support equipment are being delivered on schedule, which is 30 days prior to delivery of the related equipment.

Illustrated Parts Breakdowns (IPB's) are scheduled for completion by 1 March, 1957, vendor-prepared IPB's excepted.

4. AN/APW-17 DIRECTOR AIRCRAFT GUIDANCE

Maintenance handbook negatives on the AN/APW-17 (system No. 107) have been delivered on schedule. All IPB's, except two awaiting vendor data, have been delivered on schedule.

5. HANDBOOK REVISIONS

A program has been initiated in which handbooks already delivered will be revised to reflect (1) additional component configurations (dash numbers added to Bell drawings) and (2) changes resulting from handbook/equipment evaluation programs under way at Bell Aircraft facilities.

APPENDIX I

FACILITIES

1. SYNOPSIS

Various facilities are operated by the Bell Aircraft Corporation in developing, manufacturing, and testing the Rascal Weapon System. Principal activities and functions are: research, development, and research flight-testing at the Bell Aircraft Wheatfield Plant near Niagara Falls, New York; rocket engine and GAM-63 systems testing at nearby Air Force Plant No. 38; and final testing of the Rascal Weapon System at Holloman Air Development Center, New Mexico.

2. FACILITIES IN THE NIAGARA FRONTIER

Rascal weapon activities at Bell Aircraft facilities in the Niagara Frontier area include the design development, fabrication, and testing of:

(1) GAM-63 missiles and missile systems

(2) Equipment for R&D and trainer aircraft

(3) Rascal guidance equipment for operational director aircraft

(4) Ground support equipment

(5) Classroom demonstrators and other training aids

Also among the activities in the Niagara Frontier are the training of Air Force personnel, a GAM-63 training program, and operational weapon support equipment studies.

a. Wheatfield Plant

The Bell Aircraft facility at Wheatfield, New York, Figure 24, is the nerve-center of the MX-776 program. This plant, together with the other engineering and manufacturing facilities, fulfills, the requirements for both developing and producing elements of the GAM-63 Weapon System. The Wheatfield Plant is located adjacent to the Niagara Falls Municipal Airport where extensive development flight-testing of electronic systems is conducted. The administrative offices of the MX-776 Program, as well as functional laboratories and sections covering the fields of Aerodynamics, Dynamics, Structures, Electronics, Servo-

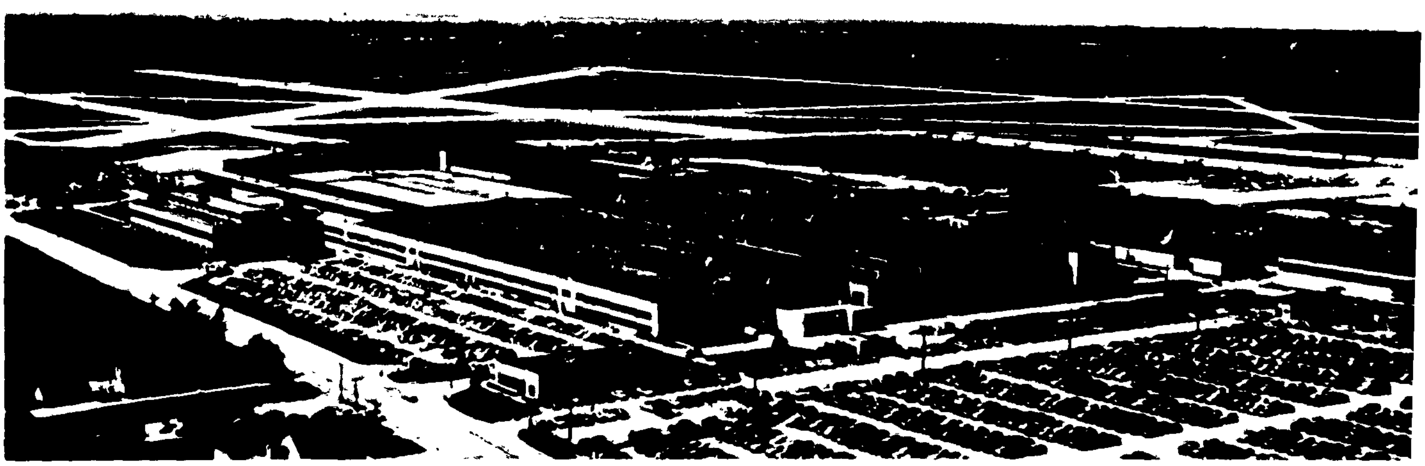


Figure 24. Bell Aircraft Plant at Wheatfield, New York

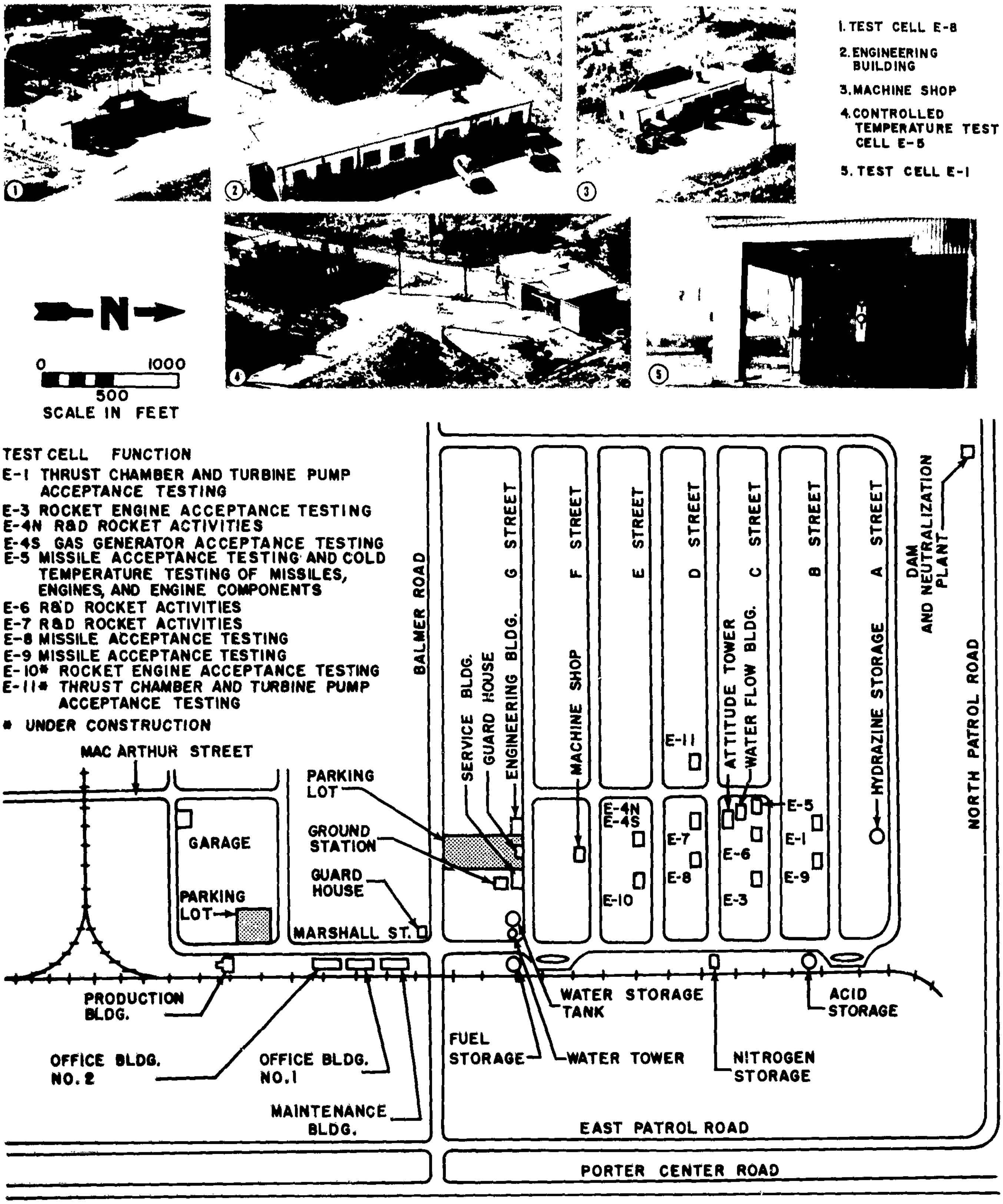


Figure 25. Plan View and Typical Installations at AF Plant No. 38

mechanisms, and Rockets are located here. In support of research and manufacturing activities are additional facilities such as rocket test cells, environmental chambers, vibration equipment, a wind tunnel, analogue computers, and automatic computation equipment. Other supporting activities, such as purchasing, subcontracting, estimating, and accounting, are also situated here.

b. Air Force Plant No. 38

A major testing facility operated by Bell Aircraft, AF Plant No. 38 is situated approximately 12 miles from the main plant at Wheatfield, New York. This area, formerly utilized for the manufacture and storage of TNT during World War II, is a site for testing missiles, rocket propulsion systems, and other components. The plant consists of 56 earth-covered concrete igloos, test cells, officies, railroad sidings, surfaced roadways, power lines, and supporting installations. This facility is used chiefly for the production acceptance testing of Rascal power plants and for checking the component systems of each GAM-63 prior to shipping the missile to Holloman Air Development Center. Air Force Plant No. 38 (see Figure 25) is also used as a proving ground for Rascal ground support equipment.

Work on two additional test cells is continuing. The new cells, designated E-10 and E-11, will be used for acceptance testing rocket engines, thrust chambers, and turbine pumps. Installation of the test cells and construction of the control room are essentially complete.

Installation of a high-speed digital data-handling system in Cells E-10 and E-11 (mentioned in previous Quarterly Progress Report) is well under way. Thirty newly designed high-speed Leeds & Northrop (Model H) indicators with shaft digiters were installed in the control room of Cell E-11. Patch panels of the telephone and switchboard type, routing incoming and outgoing signals, were erected in the control rooms of E-10 and E-11. Delivery acceptance of the first high-speed printer, with a capability of printing 3600 characters per second, was made at the vendor's Boston plant before shipment of the unit to California for marriage with the control electronics at the vendor's Berkeley plant. Work on this unit and on the second high-speed printer is scheduled for completion during the next quarter.

Construction is under way to increase the testing capability of AF Plant No. 38. The internal security fence is being moved 430 feet west and 500 feet north to increase the enclosed area to 220 acres. The new boundaries will enclose 12 additional igloos.

c. Air Force Plant No. 40

Following negotiations with the Air Materiel Command, Bell Aircraft was granted right-of-entry to a portion of Air Force Plant No. 40 to establish a Logistics (Maintenance and Supply) Depot for the Rascal Weapon System. Located in the township of Tonawanda, New York, this contractor-operated facility, Figure 26, comprises approximately 50,000 square feet of floor space. The Air Force approved a proposal for rehabilitating and equipping this fa-

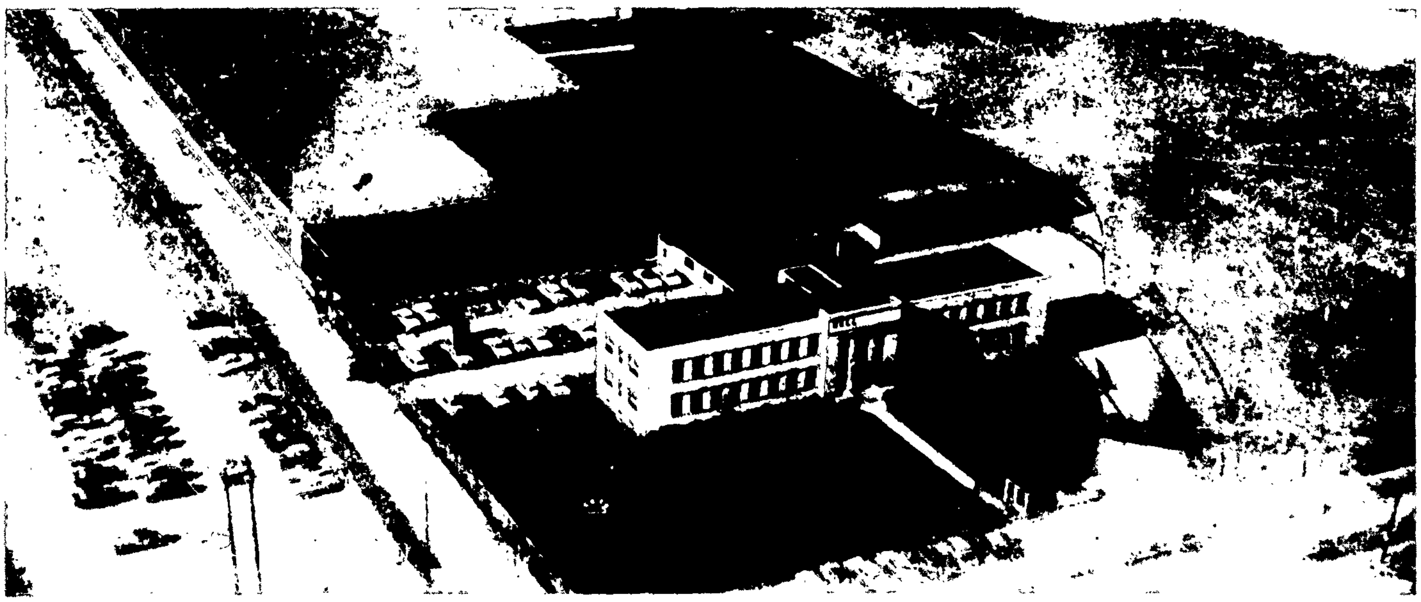


Figure 26. Contractor – Operated Logistics Depot, AF Plant No. 40

cility for the storage, maintenance, and distribution of GAM-63 missile components and related equipment. Appropriate areas of the plant have been partitioned and outside fencing has been erected in the interest of military security. Deliverable depot items are being stocked and procurement of facility equipment to operate the depot is well under way.

3. HOLLOMAN AIR DEVELOPMENT CENTER

The final flight testing of GAM-63's is conducted at the missile test range, Holloman Air Development Center (HADC), New Mexico. The Bell Aircraft facility and ramp area is shown in Figure 27. Also, conducted here are captive flights of missiles, guidance tests and evaluations with DB-36, DB-47, and JF-80 aircraft, and flights to familiarize Air Force personnel with various aspects of the Rascal Weapon System.

Included in the Bell Aircraft facilities at HADC are laboratory, shop, warehouse, and missile assemblying and servicing stations. The flight test program is supported by the HADC range instrumentation which includes Askania cinetheodolite stations, radar tracking stations, a radar network, a telemetering ground station, a mobile telemetering relay station, and motion picture camera installations. Data collected from GAM-63 captive flights and hot firings are reduced and forwarded to the Wheatfield plant so that pertinent information affecting design, performance, reliability, and safety of the weapon system may be quickly noted and integrated into the development program.

To permit the over-all testing of four missiles per month (i.e., testing at the Wheatfield plant, at AF Plant No. 38, and at HADC), 17 test positions (stations) are utilized. All stations have been modified to accommodate missiles equipped with the YLR-67-BA-9 power plant. Stations F, G, X, and Y, modified for the -9 engine configuration, are being used to test missile No. 79. Station H has been reactivated for testing missile No. 61.

At the request of the USAF, the target at North Impact Point (NIP) has been moved approximately four miles south. Work is under way to align the NIP reflectors in azimuth and tilt.

To facilitate the unloading of missiles from JB-50 ferry airplanes, 12 inches of cement has been added to raise the bottom of the south loading pit. Heretofore, it has been necessary to deflate the tires and wing structs of the JB-50 so that the fully extended handling carriage could reach the missile for unloading. This hazardous condition has now been eliminated.

Figure 27. Bell Aircraft Facility and Ramp Area at HADC

APPENDIX II

LIAISON

1. CHRONOLOGICAL LISTING OF TRIPS

Offutt AFB, Nebraska	7/2	Bell Aircraft interest areas in GAM-63
Kearfott Corporation New Jersey	7/2	Evaluation of Kearfott navigation systems
Designers for Industry Cleveland, Ohio	7/6	BLC'S: preparation, electronic part evaluation testing, electronic parts application review.
Gabriel Electronics Needham, Mass.	7/9-10	Investigation of leakage, backlash, and hydraulic motor problems
HADC, New Mexico	7/10-11	HADC complex target at NIP
Bell Aircraft Corporation Wheatfield, New York	7/11	GAM-63 fuel servicing
Bell Aircraft Corporation Wheatfield, New York	7/12	RCA magnetron (A1016)
FTL, New Jersey	7/12-13	FTL subcontract status
HADC, New Mexico	7/18-20	Target acquisition programs: RBS flight operations and procedures
Barry Controls Corporation Watertown, Mass.	7/30	All-angl isolators
Bell Aircraft Corporation Wheatfield, New York	7/30-8/10	Observation by RCA of A1016 tube usage
District Corps of Engineers Jacksonville, Florida	8/1	Review of plans for modifying Pinecastle AFB for GAM-63
FTL, New Jersey	8/3	FTL subcontract status
Bell Aircraft Corporation Wheatfield, New York	8/6	Evaluation of proposal for procurement of depot equipment
Bell Aircraft Corporation Wheatfield, New York	8/8	Agenda for Bell conference prior to Phasing Group conference at HADC
Elgin AFB, Florida	8/9	Warhead installation evaluation
HADC, New Mexico	8/15-16	Weapon System Phasing Group Conference
Bell Aircraft Corporation Wheatfield, New York	8/16	Testing equipment prior to EAST program
Bell Aircraft Corporation Wheatfield, New York	8/20	Inertial guidance power supply, high-power radar set
FTL, New Jersey	8/22	FTL subcontract: design evaluation tests
Bell Aircraft Corporation Wheatfield, New York	8/30	Specification MIL-T-J15A
WADC (WSPO) Ohio	9/5	Oxidizer tank (62-471-400) and proposal for redesigned destruct system
Bell Aircraft Corporation Wheatfield, New York	9/6	Assoc. Missile Products Corp., Pomona, Calif., weighing system for propellants
WADC (WSPO) Ohio	9/10	Bell/Boeing ECP coordination
WADC (WSPO) Ohio	9/12	Depot equipment Specification 66-947-803
Bell Aircraft Corporation Wheatfield, New York	9/19	Power plant test equipment for depot
Bell Aircraft Corporation Wheatfield, New York	9/25	GAM-63 destruct system changes

2. SUMMARY OF TRIP REPORTS

a. Weapon System Project Office (WSPO)

Destruct System

A preliminary proposal for a redesigned Rascal destruct system was reviewed at WADC in September and found to be generally acceptable by the WSPO. It was agreed that Bell Aircraft would prepare a final engineering proposal, including development costs and schedules, for review at WADC.

Rocket Engine Development

A conference at WADC in June 1956 reviewed configuration changes involved in developing a rocket engine utilizing IRFNA and defined contract changes required.

b. Holloman Air Development Center

RBS Flight Operations

A meeting was held at HADC on 23 July to discuss operational procedures for the RBS flights as they have developed since the beginning of the program. Prior to the meeting, RBS flights were observed at Phoenix by Bell Aircraft personnel who were impressed by the trouble-free performance of the JF-89. The meeting reviewed countdown specifications at Phoenix and at HADC and found them compatible. Navigation methods for the DB-47 and spares problems were also discussed.

Review of Complex Target at NIP

In preparation for the EAST flight program at HADC, the complex target at NIP was investigated by Bell Aircraft personnel in July 1956. Information gained is to be used in planning the program against the target.

EAST Operational Procedures

As agreed at a conference on 28 and 29 June, HADC personnel will prepare a sequence of operations for the guidance operator in accordance with the operational concept. Other subjects covered at the

conference include: release aimpoint selection, tracking circle of DB-47 at HADC, simplifying the guidance operator's functions, fuzing baro switch setting, and statistical data on wind speed and direction on a yearly basis at HADC.

c. Bell Aircraft's Wheatfield Plant

EAST Program

Testing at Bell Aircraft of equipment to be sent to Eglin AFB for the EAST ground phase will involve performing an operational countdown check on the checkout trailer (serial No. 3) and missile No. 91.

Destruct System Changes

Destruct system changes planned prior to the next firing were established in September 1956 and a schedule of beacon requirements was set up. No change in missile firing dates was anticipated because of these changes.

Repackaging

A series of conferences was held at Bell Aircraft in June 1956 to establish a course of action for procuring repackaged units from FTL for use in the A_1 program. It was decided to base the future of the Phase I program on final flight test results of the present system.

AN/APW-17 Guidance Systems

Problems attached to maintenance of system No. 107 at Boeing/Wichita and the need for a sub-depot were reviewed in June 1956. Temporary measures to provide adequate maintenance were established, and, depending upon USAF acceptance of Bell Aircraft policy, further study of maintenance on a long-term basis was planned.

Servo Component Changes

A meeting was held at Bell Aircraft to determine action necessary to incorporate changes in servo components in missile No. 91 as defined by ECC GAM-63A-1438. A review of the black box schedule established that it was possible to secure parts in time to incorporate the changes into missiles Nos. 91, 95, and subsequent.

RCA Magnetron Tube

Studies of the A1016 tube usage were made at Bell Aircraft in conjunction with RCA during July and August 1956. Three out of four tube types successfully completed acceptance tests. The unaccepted tube was returned to RCA for evaluation.

RCA agreed to send a memorandum by 1 September 1956 describing the results of their evaluation of certain equipment design changes made by Bell Aircraft to improve tube reliability, such as the ferrite isolator, low impedance output modulator, and reduced accelerator grid bias.

Inertial Guidance Power Supply – High-Power Radar Set

It was decided at a conference in August 1956 that the current redesign of the servo power supply would be reviewed to determine the changes necessary to consolidate (1) the 300-volt supply for the inertial guidance system and (2) the servo power supply.

DEPARTMENT OF THE AIR FORCE

HEADQUARTERS AERONAUTICAL SYSTEMS CENTER (AFMC)
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

29 Dec 09

88 CS/SCOKIF (FOIA)
3810 Communications Blvd
Wright-Patterson AFB OH 45433-7802

Defense Technical Information Center
Attn: Ms. Kelly Akers (DTIC-R)
8725 John J. Kingman Rd, Suite 0944
Ft Belvoir VA 22060-6218

Dear Ms. Akers

This concerns the following Technical Report:

Technical Report number: AD113976
Technical Report Title: Quarterly Progress Report
Technical Report Date: 30 Sep 1956
Previous classification/distribution code: UNCLAS

Subsequent to WPAFB FOIA Control Number 2009-00463, the above record has been cleared for public release.

The review was performed by the following Air Force organization: AFRL/RB and 88 ABW/IPI.

Therefore, the above record is now fully releasable to the public. Please let my point of contact know when the record is available to the public. Email: darrin.booher@wpafb.af.mil If you have any questions, my point of contact is Darrin Booher, phone DSN 787-2719.

Sincerely,

Karen McNeil

KAREN COOK
Freedom of Information Act Manager
Base Information Management Section
Knowledge Operations

3 Attachments
1. FOIA Request # 2009-00463
2. Citation & Cover sheets of Technical Report #AD113976
3. Copy of AFMC Form 559